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SPACE GENERIC OPEN AVIONICS ARCHITECTURE
(SGOAA)
STANDARD SPECIFICATION

December1993

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Prepared by:

Lockheed Engineering & Sciences Company
Houston, Texas

Job Order 60-911
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for

FLIGHT DATA SYSTEMS DIVISION
JOHNSON SPACE CENTER

LESC-30354-B

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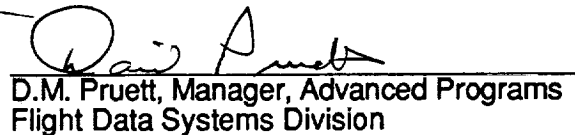December 1993

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DOCUMENT CHANGE RECORD

The following table summarizes the change activity associated with this document.

ISSUE AND DATE	CHANGE SUMMARY	SECTION

PREFACE

This document has been produced by Mr. Richard B. Wray and Mr. John R. Stovall of Lockheed Engineering and Sciences Company (LESC), the codevelopers of the avionics architectures and standards represented in this document. The contributions of Mr. Ben Doeckel of LESC who participated in early development of the concepts for the avionics architectures and standards represented in this document is acknowledged. Special acknowledgment is also given to Mr. Dave Pruett of the Johnson Space Center for his support of the Advanced Architecture Analysis, assistance in the development of the avionics architecture and constructive criticisms of the proposed standard.

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FIGURES

ACRONYMS

AP	Application Platform
API	Application Program Interface
BIT	Built-In-Test
BITE	Built-In-Test Equipment
C&T	Communications and Tracking
EE	External Environment
EEI	External Environment Interface
EIA	Electronics Industries Association
EP	Embedded Processor
FB+	Future Bus Plus
FDDI	Fiber Data Distribution Interface
GAP	General Avionics Processor
GN&C	Guidance, Navigation and Control
I/O	Input/Output
ISA	Instruction Set Architecture
IOSM	Input/Output Data Services Manager
JSC	Johnson Space Center
LESC	Lockheed Engineering & Sciences Company
NSM	Network Services Manager
OS	Operating System
OSE	Open System Environment
OSI	Open Systems Interconnect
POSIX	Portable Operating System Interface
RTE	Run Time Environment

SAP	Special Avionics Processor
SDS	Space Data System
SDSS	Space Data System Services
SGOAA	Space Generic Open Avionics Architecture

1. INTRODUCTION

1.1 SCOPE

This standard establishes a Space Generic Open Avionics Architecture (SGOAA) interface model and the requirements for applying this model to the development of spacecraft core avionics systems. (This version of the SGOAA standard primarily addresses the general avionics processors and their interfaces. Internal interfaces for special avionics processors and embedded processors require further definition.)

1.2 PURPOSE

The purpose of this standard is to provide an umbrella set of requirements for applying the generic architecture interface model to the design of a specific avionics hardware/software system. This standard defines a generic set of system interface points to facilitate identification of critical interfaces and establishes the requirements for applying appropriate low level detailed implementation standards to those interfaces points. The generic core avionics system and processing architecture models provided herein are robustly tailorable to specific system applications and provide a platform upon which the interface model is to be applied.

1.3 APPLICATION GUIDANCE

This standard is intended to be used by both avionics system designers and avionics system implementors in the development of open systems architectures for avionics. The system under design shall be expressed in the context of the System Architecture and Generic Processing Architecture as defined in Sections 5.1 and 5.2.1.2 respectively of this standard. The Architecture Interface Model shall be directly applied to identify the specific interfaces requiring application of lower level standards. The selection of specific lower level standards is dependent upon unique system requirements, but shall be conducted in accordance with the guidelines provided in Section 4.2.

This architecture is scaleable and recursive, and can be applied to any hierarchical level of hardware/software processing system, as discussed in Section 6.6.

1.4 **BACKGROUND**

Development of a SGOAA that satisfies the Portable Operating System Interface (POSIX) reference model [POSIX91], the Open System Interconnect (OSI) reference model [ISO7498] and the definition of an open system architecture was initiated to aid in providing the following benefits to future space programs:

- Provide the basis for establishing a set of specifications, standards and procedures that will become common to all systems used in simultaneously operational missions, e.g., to simplify interfaces between multiple vehicles (such as the shuttle and station) when performing a joint mission such as docking.

- Ensure that future avionics systems can be upgraded and maintained with minimal redesign impact to the existing avionics system by establishing the interfaces required to enable modular replacement of hardware and software.

- Promote availability of multiple sources of needed avionics software and hardware by defining standard interfaces.

- Provide a pool of hardware and software modules for multiple program re-use by defining standard interfaces and promoting hardware and software reuse and commonality.

- Insure access to the architecture and its design documentation for any vendor or agency desiring to propose new uses and applications, and to facilitate competition to contain cost growth.

A complete description of the SGOAA development model, technical considerations and application examples is contained in the technical guide [WRA93].

2. APPLICABLE DOCUMENTS

The following documents provide additional supplemental material applicable to this standard. They provide additional requirements or expand on requirements from this standard for generic open architectures.

2.1 STANDARDS

[ISO7498]   "Information Processing Systems - Open Systems Interconnection - Basic Reference Model", First Edition, International Standards Organization, October 1984.

[POSIX91]   "Draft Guide to the POSIX Open Systems Environment", P1003.0/D14, IEEE Computer Society, November 1991.

[SYSB-1]   "Systems Engineering", EIA Engineering Bulletin SYSB-1, Electronics Industries Association (EIA), December 1989.

2.2 SPECIFICATIONS

2.2.1 GOVERNMENT SPECIFICATIONS

[JSC 31000]   Space Station Projects Description and Requirements Document, Vol. 3, Rev G, 4 April 1991.

[SSP 30235]   Space Station Program Glossary, Acronyms and Abbreviations, CR BB007008A, No date

[PAVE PILLAR]   "Architecture Specification for PAVE PILLAR Avionics", SPA-90099001A, Aeronautical Systems Division, USAF, January 1987.

2.2.2 CONTRACTOR SPECIFICATIONS

2.3 OTHER PUBLICATIONS

[BOE91]   Flanagan, Rich and Van Ausdal, Art, "SATWG Flight Data System Architecture Specification Outline" briefing, 25 October 1991

[BOOCH87]   Booch, Grady, "Software Engineering with Ada", 2nd Edition, Benjamin Cummings Publishing Comp., 1987.

[GD90A]   General Dynamics "Space Avionics Requirements Study", 21 October 1990, Contract NAS8-37588, TD006 Presentation Package, as briefed to the SATWG

[LAP90]   Laprie, J. C., "Dependability: Basic Concepts and Terminology", J. C. Laprie - Editor, Published by International Federation for Information Processing (IFIP) Working Group 10.4 on Dependable Computing and Fault Tolerance, December 1990.

[WRA93]   Wray, R. B. and Stovall, J. R., "Space Generic Open Avionics Architecture (SGOAA) Reference Model Technical Guide", Job Order 60-430, Contract NAS9-17900 for the JSC, NASA CR-188246, LESC-30347-A, April 1993.

3. DEFINITIONS

Definitions are taken from the [POSIX91] or [LAP90] where applicable or otherwise established as shown.

3.1 APPLICATION

Application is defined as the use of capabilities (services/functions) provided by an information system specific to the satisfaction of a set of user requirements. [POSIX91]

3.2 APPLICATION PLATFORM

Application Platform (AP) is defined as the set of resources that supports the services on which an application or application software will run. Also known as a host platform. [POSIX91]

3.3 APPLICATION PROGRAM INTERFACE

Application Program Interface (API) is defined as the interface between the application software and the application platform, across which all services are provided. [POSIX91]

3.4 APPLICATION SOFTWARE

Application Software is defined as software that is specific to an application and is composed of programs, data and documentation. Application software has uniquely defined interfaces. [POSIX91]

3.5 ARCHITECTURE

Architecture is defined for this standard as the structure of Application Software, API, AP, and External Environment Interfaces (EEIs) which describe the organization and interfaces of a system.

3.6 AVAILABILITY

Availability is a measure of the probability that a designated system will delivery the correct service when called upon at any random point in time. [Adapted from LAP90]

3.7 AVIONICS SYSTEM

Avionics System is defined for the purpose of this standard as the set of all electronic and processing based subsystems on a space vehicle, including all hardware, software and other electronics needed to control and operate the space vehicle. It is the collection of system elements and allocated capabilities that provides the coordinated functionality for end-to-end processing in handling the information needed to interface the space vehicle's major components, to control its interaction with its environment, and to respond to human commands. (Adapted from [JSC 31000])

3.8 COMMUNICATION INTERFACE

Communication Interface is defined as the boundary between application software and the external environment, such as application software on other host platforms, external data transport facilities and devices. The communications interface may be internal to one space vehicle or across multiple space vehicles. [POSIX91]

The services provided are those whose protocol state, syntax and format all must be standardized for interoperability.

3.9 COMPONENT

Component is one of the parts resulting when an entity is decomposed into constituent parts.

3.10 CONTINUITY

Continuity is defined to mean that requirements changes are proportional to design changes, i.e., that changes in the requirements will propagate into changes of the same order of magnitude in the design.

3.11 CONTROL SYSTEM

Control Subsystem is an application which selects and implements alternative actions based on a-priori criteria or real time guidance.

3.12 CORE AVIONICS

Core Avionics is defined as the control subsystems and the supporting avionics (hardware and software) needed to enable these control subsystems to function. Core avionics include the controls for each of the traditional space avionics hardware subsystems (such as Guidance Navigation and Control (GN&C) and Communications and Tracking (C&T)). The avionics hardware sensors and effectors are outside the core avionics boundary.

3.13 DATA

Data are the sensor outputs to the system, input to applications from the system, output from applications to the system, input to crew or operations control elements from the system, outputs from crew or operations control elements to the system. Data may include commands.

3.14 DATA BASE MANAGER

Data Base Manager is the control subsystem which manages structured data files, file transfers and file redundancy management.

3.15 DATA PROCESSING SYSTEM

Data Processing Subsystem is an application subsystem providing data processing services. Data processing subsystems do not perform control subsystem functions.

3.16 DATA SYSTEM

Data System (for example the Space Data System - (SDS)) is a network of data system services, onboard computational resources, data storage, and human-machine interface devices which provide onboard command and control, data transmission, computation/processing, and operating application software to support a space vehicle's users (crew and controllers), interfacing systems, applications and subsystems.

3.17 DATA SYSTEM SERVICES

Data System Services (for example the Space Data System Services - (SDSS)) is a service subsystem with a generic functional architecture designed to provide a comprehensive set of services to all vehicles and subsystems.

3.18 DATA SYSTEM MANAGER

Data System Manager is the control subsystem which manages the housekeeping and status control services for the SDSS.

3.19 DECOMPOSABILITY

Decomposability is defined to mean requirements can be broken into smaller pieces with potentially simpler solutions or at least better understanding and a capability for further decomposition as needed.

3.20 DEGRADED MODE

Degraded mode is a system condition wherein some system elements (such as hardware, software, human, or procedural) are sufficiently unhealthy that the system cannot operate normally.

3.21 DEPENDABILITY

Dependability is defined as the trustworthiness of an avionic system such that reliance can justifiably be placed on the service it delivers. Depending on the application(s) intended for the system, different emphasis may be put on different facets of dependability, i.e. dependability may be viewed according to different, but complementary, properties, which enable the attributes of dependability to be defined:

- with respect to the readiness for usage, dependable means available;

- with respect to the continuity of service, dependable means reliable;

- with respect to the avoidance of catastrophic consequences on the environment, dependable means safe;

- with respect to the prevention of unauthorized access and/or handling of information, dependable means secure. (Derived from [LAP90]).

3.22 DIRECT INTERFACE

Direct Interface is defined as the connection between an entity sending or receiving data with another entity receiving or sending data for transmission of the same data along the routing path associated with moving data from the source of the data to the end user of the

data. Data is used by an entity in a direct manner if it passes the data on without changing the data; thus, for example, network operating systems are direct interfaces between applications when they package or unpack data and send it to another network node.

3.23 DISTRIBUTED SYSTEM

Distributed System is a collection of computers, memories, buses and networks that are concurrently operating in a cooperative manner and communicating with each other.

3.24 END-USER

End-user of data is the last entity which makes a significant transformation, conversion or operation on the data.

3.25 ENTITY

Entity is an abstract element that represents an object in the real world, its data attributes and essential services with their respective performance and quality characteristics.

3.26 ERROR

Error is defined to be that part of the system state which is liable to lead to subsequent failure. [LAP90]

3.27 ERROR PROCESSING

Error Processing is defined to be the actions taken in order to eliminate errors from a system. Error processing is error detection followed by either error recovery or error compensation. Error recovery replaces an error-free state for the erroneous one. Error compensation uses the redundancy of the state to enable the delivery of an error free service from the erroneous (internal) state. [LAP90]

3.28 EXTERNAL ENVIRONMENT

External Environment (EE) is defined as a set of external entities with which the application platform exchanges information. These entities are classified into the general categories of human users, information interchange entities and communication entities. [POSIX91]

3.29 EXTERNAL ENVIRONMENT INTERFACE

External Environment Interface (EEI) is defined as the interface between the application platform and the EE across which information is exchanged. The EEI is defined primarily in support of system and application interoperability. This interface consists of human/computer interaction services, information services, and communications services. [POSIX91]

3.30 EXTENSIBILITY

Extensibility is the ability of an architecture to be extended or adapted to new conditions, changes in specifications or new technologies.

3.31 FAILURE

Failure is defined as a deviation of the delivered service from the specified service, where the service specification is an agreed description of the expected function and/or service. [LAP90]

3.32 FAULT

Fault is defined as the adjudged or hypothesized cause of an error. [LAP90]

3.33 FAULT TOLERANCE

Fault Tolerance is defined as providing a service complying with the specification in spite of faults. Fault tolerance is carried out by error processing and fault treatment. Error processing is aimed at removing errors from the system state, if possible before failure occurrence; fault treatment is aimed at preventing faults from being activated -- again. [LAP90]

3.34 FAULT TREATMENT

Fault Treatment is defined to be the actions taken in order to prevent a fault from being re-activated. The first step in fault treatment is fault diagnosis, which consists of determining the cause(s) of error(s), in terms of both location and nature. This is followed by fault passivation, which prevents the fault from being activated again. If the system is no longer

capable of delivering the same service as before, then a reconfiguration may take place. [LAP90]

3.35 FLIGHT CRITICAL FUNCTION/INTERFACE

Flight Critical Function is a function or interface which, if it fails, could cause loss of vehicle control resulting in loss of the vehicle and, if present, crew. The function or interface is characterized by the presence of hard deadlines (usually in the range of milliseconds), where missing a deadline is a failure.

3.36 FUNCTION

Function is an action/task that the system must perform to satisfy customer and end user needs. Control of mission critical functions may require hard deadlines, where missing a deadline is a failure.

3.37 GENERIC ARCHITECTURE

Generic Architecture is an architecture where the elements of the architecture do not depend on any one mission or program for their definition. The elements of a generic architecture can be tailored to apply to many different missions and programs.

3.38 HUMAN/COMPUTER INTERFACE

Human/Computer Interface is the boundary across which direct interaction between a human being and the application platform take place.

3.39 INTERFACE

Interface is the shared boundary between two functional units, defined by functional and other physical characteristics, as appropriate.

3.40 INTEROPERABILITY

Interoperability is defined as the ability of two or more systems to exchange information and to mutually use the information that has been exchanged. [POSIX91]

3.41 LOGICAL INTERFACE

Logical Interface is defined as the requirements associated with establishing a data interchange interface between a source of data and the end user of the data. The end user of the data must be identified to include the requirements for the data and the source supplying the data must also be identified. Data routing is transparent to logical interface entities. Routing of the data should not be a concern to the source and end user because the routing (i.e., direct requirements) is transparent to these entities.

3.42 MISSION CRITICAL FUNCTION/INTERFACE

Mission Critical Function or Interface is any function or interface which, if it fails, results in an incomplete mission, a mission abort or a loss of payload.

3.43 MISSION READY MODE

Mission Ready Mode is a system condition wherein all system elements, including hardware, software, human and procedural, are available to enable the system to perform its intended function and the current mission for which it is intended.

3.44 MODE

Mode is a predefined set of hardware and software configurations, and associated procedures used to organize and manage the conditions of operation for an avionics system's behavior, as planned, pre-planned or directed by a human.

3.45 MODULAR ARCHITECTURE

Modular Architecture is an architecture composed of discrete components such that the design of one component depends only on the interface to other components, not on their internal design. A modular architecture is decomposable, understandable, protected, has continuity and is organized in a robust structure. It is desirable that a change in one component has minimal impact on other components. (Adapted from [SSP 30235]).

3.46 NETWORK SERVICES MANAGER

Network Services Manager (NSM) is a control subsystem which manages peer-to-peer communication between application software running on distributed processing elements communicating over a network.

3.47 OBJECT

Object is something perceptible to the sense of vision or touch or to the mind.

3.48 ONBOARD HEALTH MANAGEMENT

Onboard Health Management is defined as the hardware and software used to monitor and control on board Avionics System resources to prevent or respond to system failure. This includes the ability to efficiently monitor, checkout, and test the Avionics System, Core Avionics, and related non-avionics subsystems before, during, and after operation, as applicable. Onboard health management supports, as required, reconfiguration of Avionics System resources to prevent catastrophic failure.

3.49 OPEN FORUM

Open Forum is defined as the review of a subject in a public consensus process.

3.50 OPEN SPECIFICATION

Open Specifications are defined as public specifications that are maintained by an open, public consensus process to accommodate new technologies over time and that are consistent with international standards. The public consensus process for open specifications must be maintained and accepted by an open forum. [POSIX91]

3.51 OPEN SYSTEM

Open System is defined as a system that implements sufficient open specifications for interfaces, services, and supporting formats to enable properly engineered application software: [POSIX91]

- to be ported with minimal changes across a wide range of systems
- to interoperate with other applications on local and remote systems
- to interact with users in a style that facilitates user portability

3.52 OPEN SYSTEM INTERFACE STANDARDS

Open System Interface Standards are standards that provide for open specifications of open systems.

3.53 OPEN SYSTEM APPLICATION PROGRAM INTERFACE

Open System Application Program Interface is defined as a combination of standards-based interfaces specifying a complete interface between application software and the underlying application platform. This is divided into the following parts: [POSIX91]

- Human/Computer Interaction Services API
- Information Services API
- Communication Services API
- System Services API

3.54 OPEN SYSTEMS ARCHITECTURE

Open Systems Architecture is defined as an architecture for an open system using open specifications. It consists of a structure of interconnected functional subsystems (i.e., black boxes) using non-proprietary communications, based on open specifications for interfaces, and providing high level standard services. The interface between the application software and the underlying application platform must be based on an Open System Application Program Interface.   To be open, the architecture must be extensible through the addition of subsystems, services and resources following open specification rules.

3.55 OPEN SYSTEM ENVIRONMENT

Open System Environment (OSE) is defined as the comprehensive set of interfaces, services and supporting formats, plus user aspects for interoperability or for portability of applications, data, or people, as specified by information technology standards and profiles. [POSIX91]

3.56 OPERATING SYSTEM

Operating System (OS) is the layer of software that isolates services and application software from the application platform hardware element. The OS provides services for at least management, allocation, and deallocation of the processor, memory, timing and input/output (I/O) processing resources for application and service software.

3.57 OPERATIONALLY READY MODE

Operationally Ready mode is a system condition wherein most system hardware, software, human and procedural elements are functioning correctly, but not all subsystems are configured as needed for a mission to be performed.

3.58 PLATFORM

See Application Platform definition.

3.59 PORTABILITY

Portability is defined as the ease with which software can be transferred from one platform, application or information system to another. [POSIX91]

3.60 PROFILING

Profiling is the process of selecting a set of one or more base standards, and where applicable, the identification of chosen classes, subsets, options, and parameters of those base standards, necessary for accomplishing a particular function. (The profile selection process is discussed in section 6 of [POSIX91]).

3.61 PROTECTION

Protection is defined to mean that the architecture will limit the effect of abnormal conditions in design elements at run-time to just the affected modules or as a minimum will limit the propagation of abnormal conditions.

3.62 RED-TAGGED MODE

Red-tagged mode is a system condition wherein sufficient system hardware, software, human or procedural elements are failed that the system cannot operate at all.

3.63 RELIABILITY

Reliability is a measure of the probability that an item will deliver the correct service under specified conditions without failure, for a specified period of time.

3.64 REQUIREMENTS ARCHITECTURE

Requirements Architecture is an architecture that can be tailored for design implementation based on actual system requirements.

3.65 ROBUSTNESS

Robustness is the measure of a system's ability to support continued functioning under abnormal operating conditions.

3.66 SAFETY CRITICAL FUNCTION

Safety Critical Function is any function which has an associated condition, event, operation, process, equipment or system (including software) with the potential for catastrophic injury or damage to onboard systems, life, or environment. (adapted from [SSP 30235] and [LAP90].

3.67 SERVICE

Service delivered by a system is its behavior as it is perceived by its user(s).

3.68 SERVICE SUBSYSTEM

Service Subsystem is service software on an application platform, which provides transparent services to the using control or data processing subsystem.

3.69 SOFTWARE

Software is defined as the programs, procedures, rules, and any associated documentation pertaining to the operation of a data processing system. [POSIX91]

3.70 SOURCE

Source is the originator of data passed across a logical interface.

3.71 SPACE DATA SYSTEM

See Data System definition.

3.72 SPACE DATA SYSTEM SERVICES (SDSS)

See Data System Services definition.

3.73 SPACE GENERIC OPEN AVIONICS ARCHITECTURE (SGOAA)

SGOAA is defined as the target open architecture standard being developed to provide an umbrella set of requirements for applying a generic architecture interface model to the design of specific avionics hardware/software systems. This standard defines a generic set of system interface points and establishes the requirements for applying appropriate low level detailed implementation standards to those interfaces points. The generic core avionics system and processing hardware architecture models provided by the standard are robustly tailorable to specific system applications and provide a platform upon which the generic interface model is to be applied.

3.74 INPUT/OUTPUT DATA SERVICES MANAGER

Input/Output Data Services Manager is the interface handling subsystem that manages the services that process requests for interaction between sensors, effectors, application software and other services.

3.75 STANDARD

Standard is a document established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines, or characteristics for activities or their results, aimed at the achievement of the maximum degree of order in a given context.

3.76 STANDARDIZED PROFILE

Standardized Profile is defined as a balloted formal, harmonized document that specifies a profile. [POSIX91]

3.77 SYSTEM

System is defined as the composite of equipment, material, computer software, personnel, facilities and information/procedural data that satisfies a user need. [SYSB-1]

3.78 SYSTEM HARDWARE ARCHITECTURE

System Hardware Architecture is an architecture consisting of the set of hardware resources in a configuration of distributed computers, memories, buses and network elements.

3.79 SYSTEM SOFTWARE ARCHITECTURE

System Software Architecture is an architecture consisting of the elements and interfaces between software components in a system.

3.80 SYSTEM SERVICES SOFTWARE

System Services Software is common software, independent of application software, which is needed to run application software and enable it to interface to data within a system or across the EEI. This is similar to the POSIX entity, system software, which is defined as the application independent software that supports the running of application software.

3.81 TASK

Task is defined as a software entity that is executed in parallel with other parts of a software program to perform an action. [BOOCH87]

3.82 UNDERSTANDABILITY

Understandability is defined to mean all requirements related to a subject can be found and viewed together, and individually and jointly understood by the analysts and designers.

3.83 USER

User is another system (human or physical) which interacts with the target system.

4. GENERAL REQUIREMENTS

The SGOAA shall [1] be used to determine the interface points and requirements for the control of, and information exchange between, onboard subsystems, support to the crew, and effective interfaces between onboard and offboard systems. In accordance with system requirements, a SGOAA compliant architecture shall [2] meet open standards criteria. A SGOAA compliant system architecture shall [3] provide data acquisition, data storage, data processing and data communication functions that interconnect architectural elements as shown in the functional interface diagram, Figure 4-1. Architectures developed in accordance with this standard shall [4] meet the following general requirements for developing new architectural elements and for using existing applications and mission elements.

4.1 OPEN SYSTEMS REQUIREMENTS

An architecture developed in accordance with this standard shall [1] satisfy the open systems architecture definition incorporated in this standard. The open architecture so developed shall [2] be capable of being readily expanded in functionality and performance without redesign or significant modification to the existing system. An architecture satisfying this standard shall provide information hiding, abstraction, inheritance, modularity, robustness and extensibility.

Control subsystems may be decomposed into lower level subsystems. A control subsystem usually implements a unique avionics capability. These control subsystems may have flight, mission, or safety critical functions.

4.2 LOWER LEVEL STANDARDS SELECTION

Lower level standards developed by accredited standards development organizations (which use an open forum) shall [1] be preferred in selection over those standards developed by bodies using a closed forum. Lower level standards shall [2] be selected by the process of developing a standardized profile. Architecture specifications for which there is no draft or approved standard shall [3] not be selected. One of the driving requirements for selection shall [4] be selection of a standard that provides the full range of services required to satisfy the system applications. Other factors to consider in standards selection shall [5] be degree of openness in development, stage of completion, stability, compliance with national
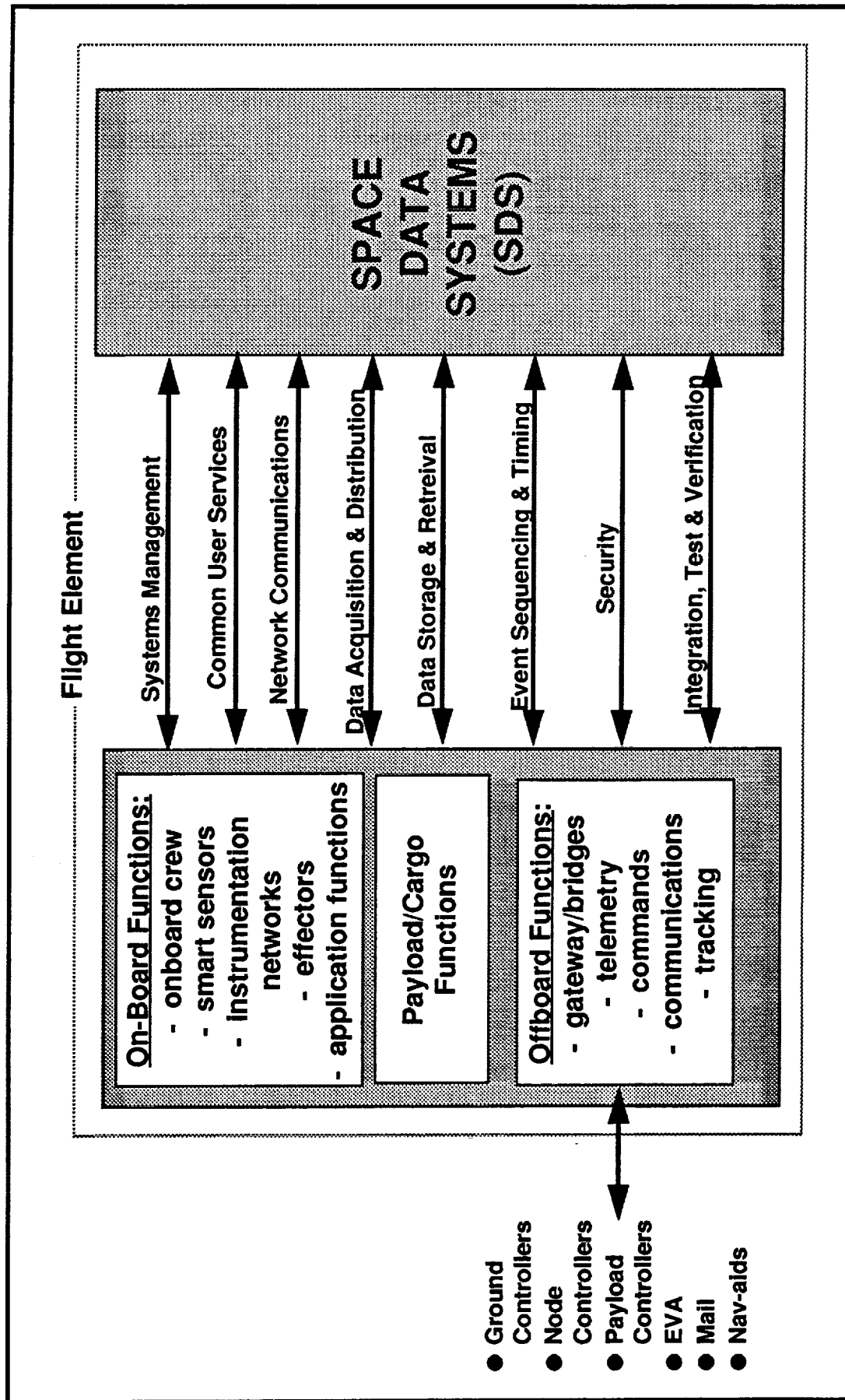
Figure 4-1. SGOAA Functional Interfaces

Flight Element

SPACE DATA SYSTEMS (SDS)

- Systems Management
- Common User Services
- Network Communications
- Data Acquisition & Distribution
- Data Storage & Retreival
- Event Sequencing & Timing
- Security
- Integration, Test & Verification

On-Board Functions:
- onboard crew
- smart sensors
- instrumentation networks
- effectors
- application functions

Payload/Cargo Functions

Offboard Functions:
- gateway/bridges
- telemetry
- commands
- communications
- tracking

- Ground Controllers
- Node Controllers
- Payload Controllers
- EVA
- Mail
- Nav-aids

and international standards, degree of satisfying a SGOAA service need, consistency with the SGOAA and availability for implementation without restrictions.

Preference shall [6] be given to existing mature standards, followed by emerging standards, and only if necessary, followed by new standards. The order of selection within these preferences is as follows:

- Approved standards developed by (a) accredited international bodies, (b) accredited regional bodies and (c) accredited national bodies.

- Draft standards developed by (a) accredited international bodies, (b) accredited regional bodies and (c) accredited national bodies.

- Recognized de facto standards and specifications developed by nonaccredited bodies using an open forum.

- Approved standards and specifications developed by nonaccredited international standards bodies using a closed forum.

- Approved standards and specifications developed by nonaccredited national standards bodies using a closed forum.

4.3 ARCHITECTURE FEATURES

An Architecture prepared in accordance with this standard shall [1] provide the following features.

4.3.1 REQUIREMENTS ARCHITECTURE

An architecture prepared in accordance with this standard shall [1] be an architecture that can be tailored for design implementation based on actual system requirements.

4.3.2 CRITICAL INTERFACES

An architecture prepared in accordance with this standard shall support [1] flight, [2] mission and [3] safety critical functions and interfaces, as required.

4.3.3 NON-CRITICAL INTERFACES

An architecture prepared in accordance with this standard shall [1] support non-critical support functions and interfaces, as required.

4.3.4 RESOURCE CONTROL

An architecture prepared in accordance with this standard shall [1] provide for control of the system resources that are used for control and information processing in onboard systems by use of system services software as requested by application software through a standard interface.

4.3.5 COMMONALITY

An architecture shall [1] be comprised of common hardware and software components to the maximum possible extent.

4.3.6 INTERFACE STANDARDIZATION

An architecture prepared in accordance with this standard shall [1] provide standard interfaces and shall [2] also allow user definable interfaces where no standards exist or standard is not applicable. Interfaces between hardware and other hardware entities shall [3] be based on standards. Interfaces between hardware and software shall [4] be based on standards. Interfaces between system services software and application software [5] shall be based on standards. The following interfaces shall [6] be prohibited in an architecture compliant with this standard: (1) direct, non-service task to task communications, and (2) applications to applications direct information exchanges, which bypass use of system services.

4.3.7 CREW OVERRIDE

For crewed vehicles, an architecture prepared in accordance with this standard shall [1] enable crew intervention, through multiple techniques, to safely override or inhibit automatic flight, mission or safety critical functions. For uncrewed vehicles, the architecture shall [2] enable ground control station intervention to safely override or inhibit flight, mission or safety critical functions.

4.3.8 ONBOARD HEALTH MANAGEMENT

An architecture compliant with this standard shall [1] provide at least health management, status monitoring and warning capability to monitor critical functions in onboard systems, subsystems, components and crew and shall [2] provide avionics system level error recovery and fault treatment for non-critical hard deadline functions. Fault tolerance shall [3] be carried out by error processing and fault treatment. System service software built-in-test (BIT) to include error detection, processing and recovery and fault treatment shall [4] be incorporated into software control modules. Hardware built-in-test equipment (BITE) to include error detection, processing and recovery and fault treatment shall [5] be incorporated into hardware modules. Error processing and recovery and fault treatment for flight critical functions shall [6] be performed at the system services software and/or hardware module level. The interface between hardware BITE and health and status applications software shall [7] be through standard software services. Error detection, processing and recovery and fault treatment shall [8] be timely enough to prevent loss of critical functions.

At least two levels of health management, status and warning capability may be provided in compliant architectures: level 1 is application software prepared for the user's platform with knowledge of the mission, system and user goals. Level 2 is service software which utilizes standard health management capabilities (i.e., in Data System Services) as defined in paragraph 4.3.9.4 of this standard.

On board health management that controls allocation of avionics system resources shall [9] be implemented in application software where knowledge of the mission or specific system is unique and cannot be entered into the table-driven health management Data System Services software . The interface between the reconfiguration hardware and the controlling application software shall [10] be through standard Data System Services software. Application software performing on board health management shall [11] be capable of overriding reconfiguration decisions made by fault tolerance functions provided in Data System Management under Data System Services.

An architecture compliant with this standard shall [12] provide operating modes for at least: (1) mission ready, (2) operationally ready, (3) degraded, and (4) red-tagged.

4.3.9 DATA SYSTEM SERVICES

An architecture prepared in accordance with this standard shall [1] include requirements for data system services. This shall [2] consist of at least requirements for input/output data services management, network services management, data base management, data system management, and an operating system.

4.3.10 GROWTH AND SPARE CAPACITY

An architecture prepared in accordance with this standard shall [1] accommodate growth and spare capacity in data storage, processing throughput, network throughput, input/output and additional sensors/effectors as required by system documentation.

4.3.11 MODULARITY

An architecture prepared in accordance with this standard shall [1] be modular.

4.3.12 SERVICE TRANSPARENCY

An architecture prepared in accordance with this standard shall [1] be implemented with sufficient transparency that the user will have visibility into the operation of services, but not necessarily the implementation of services.

4.3.13 TECHNOLOGY TRANSPARENCY

An architecture prepared in accordance with this standard shall [1] be implemented with sufficient transparency that technologies applied to design can be upgraded without revising the architecture and without negative impact on the user.

4.3.14 INTEROPERABILITY

An architecture prepared in accordance with this standard shall [1] support interoperability by providing standard interfaces between multiple programs.

4.3.15 DEPENDABILITY

An architecture prepared in accordance with this standard shall [1] meet dependability requirements in a manner that supports standard interfaces, commonality, modularity and interoperability. Such an architecture shall [2] further satisfy the following subparagraphs.

4.3.15.1 <u>Availability</u>

An architecture compliant with this standard shall [1] be designed to satisfy the specified Availability requirements of the designated system.

4.3.15.2 <u>Reliability</u>

An architecture compliant with this standard shall [1] be designed to satisfy the specified Reliability requirements of the designated item.

4.3.15.3 <u>Safety</u>

An architecture compliant with this standard shall [1] provide an interface not dependent upon avionics system specific safety features for application software that is required to be portable.

4.3.15.4 <u>Security</u>

An architecture compliant with this standard shall [1] provide an interface not dependent upon avionics system specific security features for application software that is required to be portable.

5. ARCHITECTURE INTERFACE DETAILED REQUIREMENTS

The SGOAA model is based on partitioning between logical and direct requirements as illustrated in Figure 5-1. The model is established to include architectural functions, hardware, software and interfaces for all avionics systems. This SGOAA requirements description includes both system service software and applications software for the Space Data and Operations Control Subsystems. Interfaces in this model are valid for both one platform and multi-platform architectures on one or more vehicles.

This model is to be used to define how system requirements are to be applied at the appropriate system level to determine the logical and direct interface points. System logical data flow requirements should be created for each client/server entity addressing the data attributes needed by that entity or needed to be provided for some other entity. The logical data flow requirements should identify the source of the data and the end-user needing the data, as well as the characteristic attributes required of the data. Logical data flow requirements should not be concerned with the mechanism for implementing the data interchange. Implementation related requirements for the interfaces are a direct interface issue relating to the mechanisms provided for flowing the data from the source to the end-user. Sources of the design requirements for the interfaces, application platform hardware and application platform services should be derived from the Applications Software requirements and their logical data attribute requirements based on the user's needs.

5.1 SYSTEM ARCHITECTURE REQUIREMENTS

The SGOAA System Architecture as shown in Figure 5-2 shall form the basis for creating a model of the system under development.

System architecture models shall [1] consist of a functional definition of the types of processors and communications paths required. The model shown in figure 5-2 has three types of processors interconnected by two types of communications. This model only shows one of each type of hardware; the number of instances of each type of processor is variable depending upon system unique requirements and may range for 0 to n. For example, a centralized system architecture may look just like Figure 5-2, while a distributed system architecture may have multiple General Avionics Processor (GAPs), Special Avionics Processor (SAPs) and Embedded Processor (EPs). Either type of architecture may have many

LOGICAL INTERFACE

DIRECT INTERFACES

Application Software — Entity B

Application Software — Entity A

Application Platform — Service Entity

API

EEI

NETWORK

OTHER MEDIA

External Environment
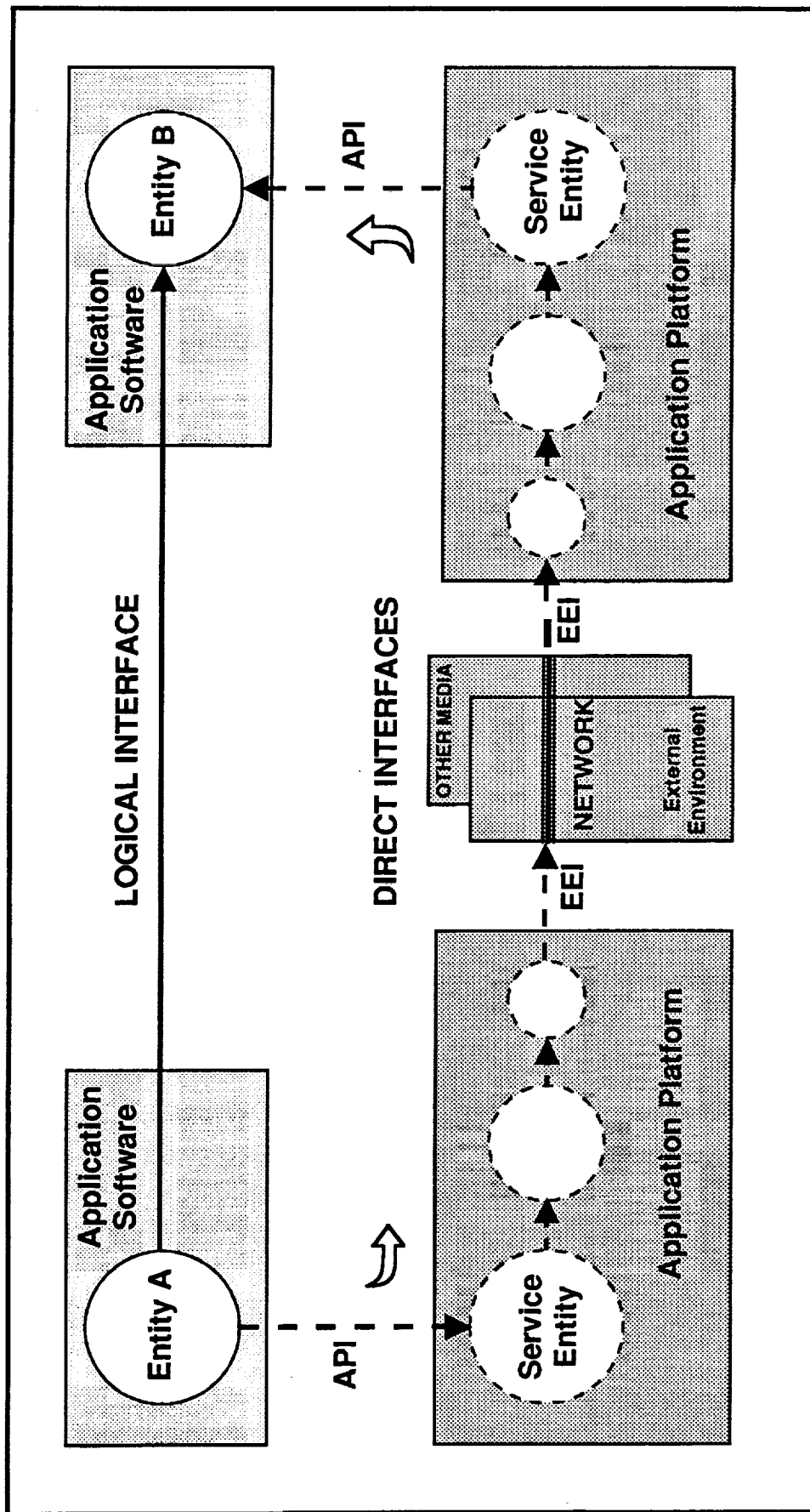
Figure 5-1. Logical System Requirements Flowdown to Direct Design Requirements
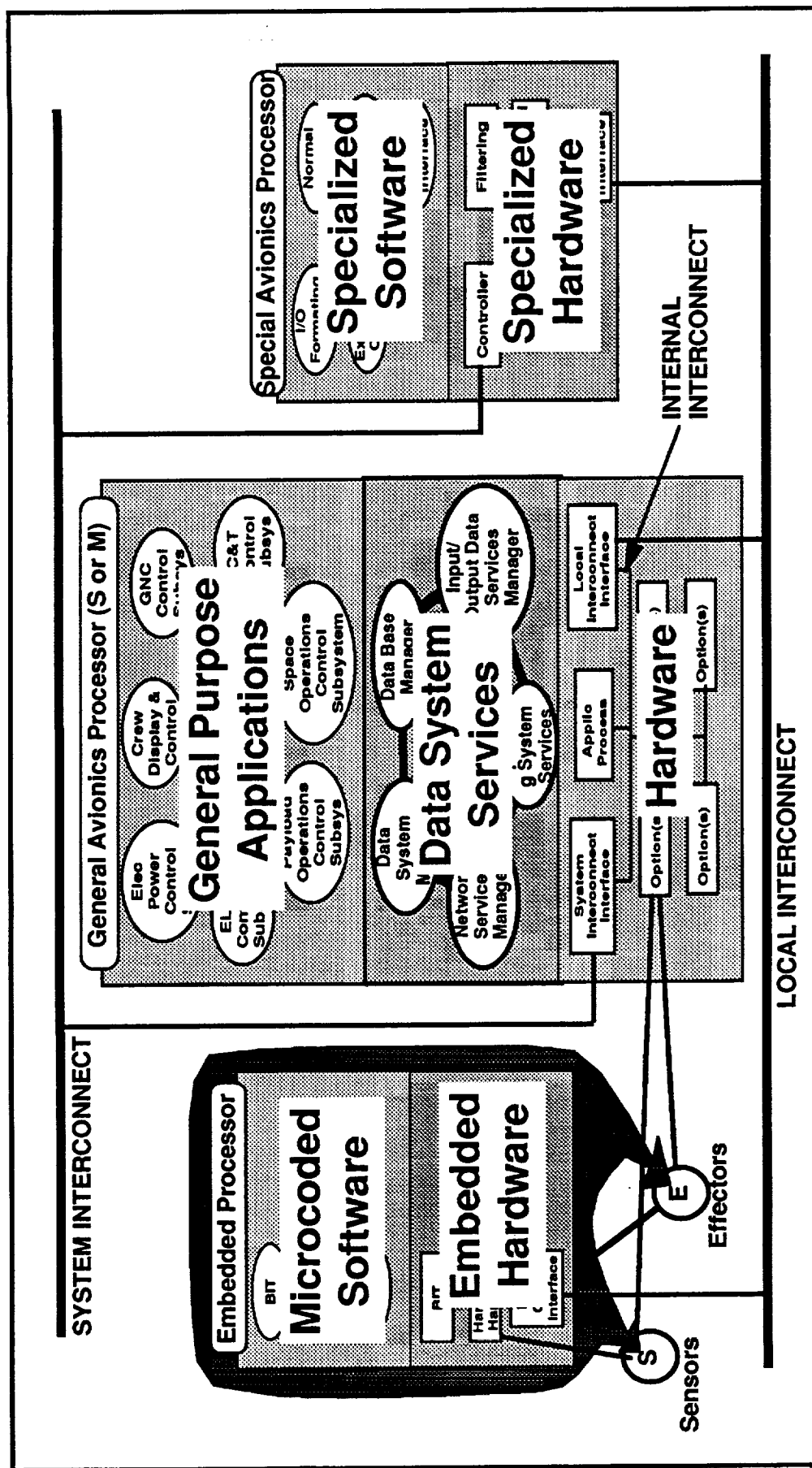
Figure 5-2. System Architecture

system interconnects and/or local interconnect mechanisms. More than one sensor and effector will usually be the rule in most non-trivial systems.

The processors shown in the system architecture in Figure 5-2 are a GAP for general purpose processing, a SAP for specialized processing support (vector/massively parallel/other), and an EP for the function of processing data within the sensor and effector devices. The sensors and effectors shown in the example may also interact directly with the main processors (the GAPs) or indirectly through EPs built into the sensors and effectors (if applicable).

Communications paths illustrated are of three types: system interconnects such as core networks for interconnecting sets of general processors or nodes, local interconnects such as local buses for interconnecting EPs and SAPs with their supported GAPs and general purpose processing applications, and internal interconnects such as backplane buses. System models shall [2] follow the general format of Figure 5-2, but shall [3] be tailored to match individual system requirements, in particular the program's application of sizing to the "system".

5.2 ARCHITECTURE INTERFACE MODEL REQUIREMENTS

An architecture compliant with the SGOAA Interface Model requirements shall [1] consist of six classes of interfaces as shown in Figure 5-3 and defined in Table 5-1. These classes are the levels of interfaces from hardware up to high level systems which are to be completely defined in an architecture developed in accordance with this standard. Definition of each interface class shall [2] be in accordance with the requirements contained in the following paragraphs.

For flight and safety critical functions, the exchange of information for error processing and control shall [3] be restricted to classes 1,2, and 3. For mission critical functions, the exchange of information for error processing and control shall [4] be restricted to classes 1,2,3, and 4. For any critical functions or service function with hard deadlines, an architecture prepared in compliance with this standard shall [5] not allow the exchange of information for error processing across Interface Classes 5 and 6. Errors introduced by data transmission are removed at the lower interface class. The data itself, however, may still have errors if the source of the data was in error. Error processing on these data error may
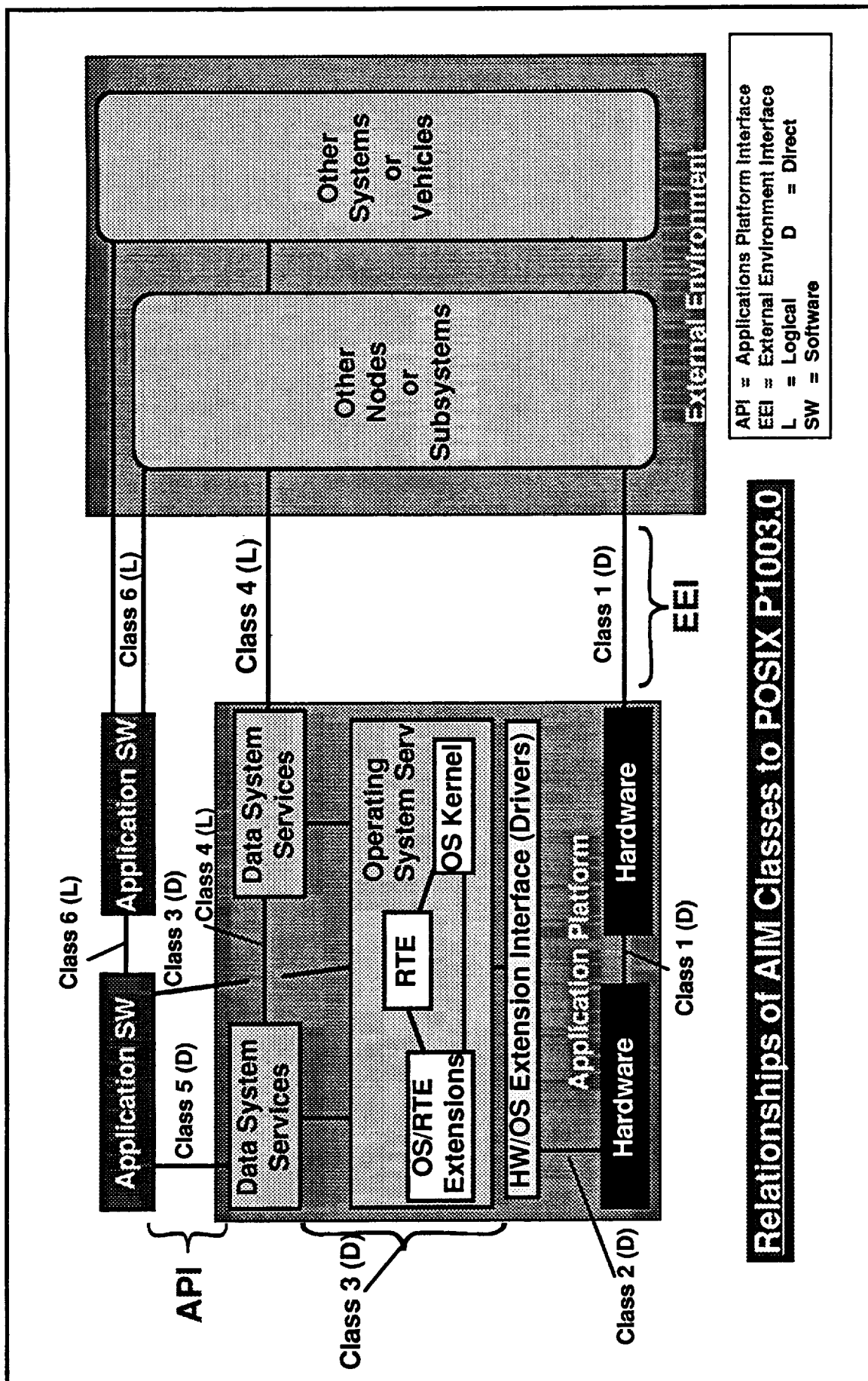
Figure 5-3. Reference Architecture Interface Model

Relationships of AIM Classes to POSIX P1003.0

API = Applications Platform Interface
EEI = External Environment Interface
L = Logical   D = Direct
SW = Software

Table 5-1. Architectural Interface Classes

CLASS	DESCRIPTION
1	**Hardware-to-Hardware Direct:** Class 1 hardware direct interfaces are the direct connections between different types of hardware such as needed to enable buses and communications links to address processors or needed to enable processors to address memory registers.
2	**Hardware-to-Operating System Extension Software Direct:** Class 2 hardware to operating system extension software direct interfaces are the direct connections between hardware registers and operating system extension service software or other software performing that function, such as drivers needed to enable address registers to move data packets from hardware to system service software, and service drivers which can respond to the data packets.
3	**Operating System Services Software-to-Software (Local) Direct:** Class 3 operating system service software to other software direct interfaces are the direct connections between operating system service code and other local software code sets, which enable operating system software to receive and interpret data packets, and pass them on to other software code which will process them locally.
4	**Data System Services Software-to-Data System Services Software Logical:** Class 4 system service software to other system service software logical interfaces are the indirect connections which enable local service software to determine the address of the intended software in other local or remote locations which need the register data being stored and to pass the data appropriately. Enables the handling of logical data transfers from source to user service
5	**Data System Services Software-to-Applications Software Direct:** Class 5 system service software to applications software direct interfaces are the direct connections which enable software service code to access and process data from local application software code.
6	**Applications Software-to-Applications Software Logical:** Class 6 applications software to applications software logical interfaces are the indirect connections which enable an application originating data to pass it to an application which needs to use the data, or enable an application needing data to determine the source from which the data must be obtained. These are logical data transfers from source to user. This interface provides the indirect connections that allow applications in different systems or in the same system to communicate, thus enabling applications software to interact across or within system boundaries to accomplish a mutual purpose. These interfaces may be applicable to applications executing in the same processor, in different processors in the same node or in different systems.

take place in the application software, but it must be understood that such error processing reduces the portability of this Application Software.

5.2.1 CLASS 1 - HARDWARE-TO-HARDWARE DIRECT INTERFACE REQUIREMENTS

The Class 1 Hardware-to-Hardware Direct Interface shall [1] be defined in accordance with the three key aspects of the class 1 direct interface: the interface architecture, the generic processing external hardware architecture, and the general avionics processor internal hardware architecture.

All types of error processing on data transmissions through the class 1 interface shall [2] be allowed.

5.2.1.1 Interface Architecture

5.2.1.1.1 Hardware to Hardware Direct Interfaces

Hardware to hardware direct interfaces shall [1] be defined as shown in Figure 5-4. These interfaces consist of the nuts and bolts, chips and wires of the system architecture model described in paragraph 5.1. With regard to the model, this interface shall [2] consist of all the hardware to hardware interfaces within each processing element, as well as the hardware interfaces to the external environment by way of the system interconnect, local interconnects , internal interconnects or direct interfaces. This architecture shall [3] provide for three classes of processors: the EPs, SAPs and GAPs for which standardized interfaces shall [4] be required to be selected from a set of acceptable lower level interface standards.

5.2.1.1.2 Hardware Architecture

The GAP architecture shall [1] be configured to provide hardware components to interface to a system interconnect, to interface to local interconnects, to process applications, perform BIT and optional components for other purposes as required by the system. The SAP architecture shall [2] be configured to provide hardware components for control, filtering, bus interface, BIT and other specialized purposes as required by the system. The EP architecture shall [3] be configured to provide hardware components for microcontrol, BIT, hardware handling and setup, and bus interface as required by the system.
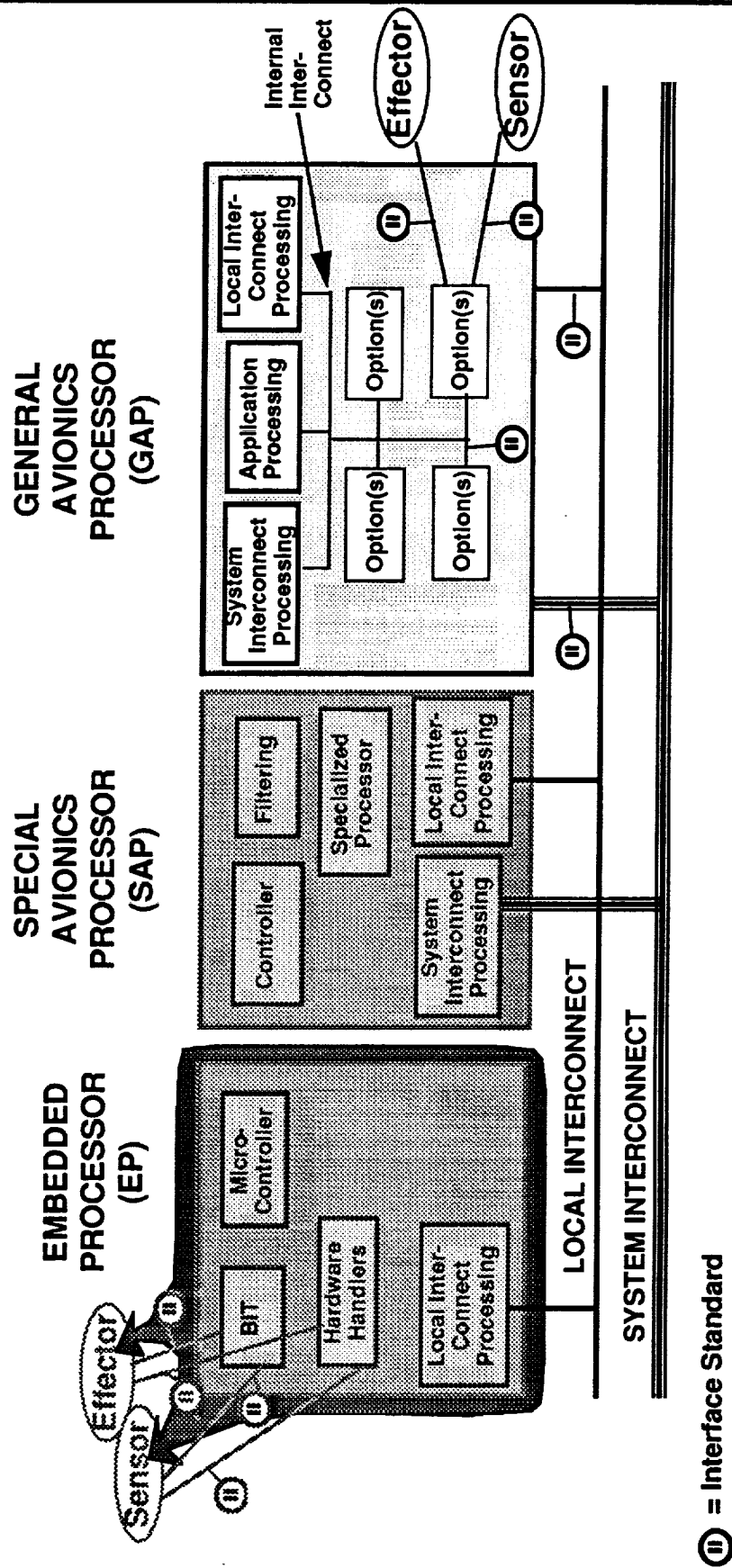
Figure 5-4. Class 1 Hardware-to-Hardware Direct Interfaces

a. The hardware architecture shall [4] provide communications from at least one of three levels of communications: Level 1, System Interconnects (e.g., Fiber Data Distribution Interfaces - (FDDI)), Level 2, Local Interconnects (e.g., MIL-STD-1553 bus and RS-449 links), and Level 3, Internal Interconnects (e.g., VME backplane). This is illustrated in Figure 5-4.

b. Level 1 system interconnects shall [5] be implemented by high capacity networks or links providing communications between host platforms using techniques such as FDDI or by direct links between high data rate elements.

c. Level 2 local interconnects shall [6] be implemented by a combinations of buses and direct links for analog, discrete or serial communications between subsystem elements or components within one host platform.

d. Level 3 internal interconnects shall [7] be implemented by a combination of backplane buses to connect devices such as circuit boards connected by VME or Futurebus+ backplanes and internal component links.

The communications from sensors or effectors to EPs are only possible through direct links because the intention of the architecture is that embedded processors are those processors embedded in the sensor or effector hardware devices to minimize the communications latencies.

5.2.1.2 Generic Processing External Hardware Architecture

The Generic Processing External Hardware Architectures shall [1] be defined as shown in the example in Figure 5-5. The architecture system interconnect represents the inter-subsystem connectivity, and can be implemented by a combination of one or more communications paths using point-to-point, ring, bus or other architecture designs. Typically, system interconnects such as core networks are implemented by lower level standards such as FDDI or Ethernet. Local interconnects provide the intra-subsystem connectivity for high speed data communications between processors within one subsystem. Typically, the local interconnects are implemented by lower level standards such as MIL-STD 1553B for local command and data buses, RS-488 for timing controls, and direct links for analog and discrete signals. The interface plugs shown represent the unique hardware interfaces which shall [2] be defined by standards.
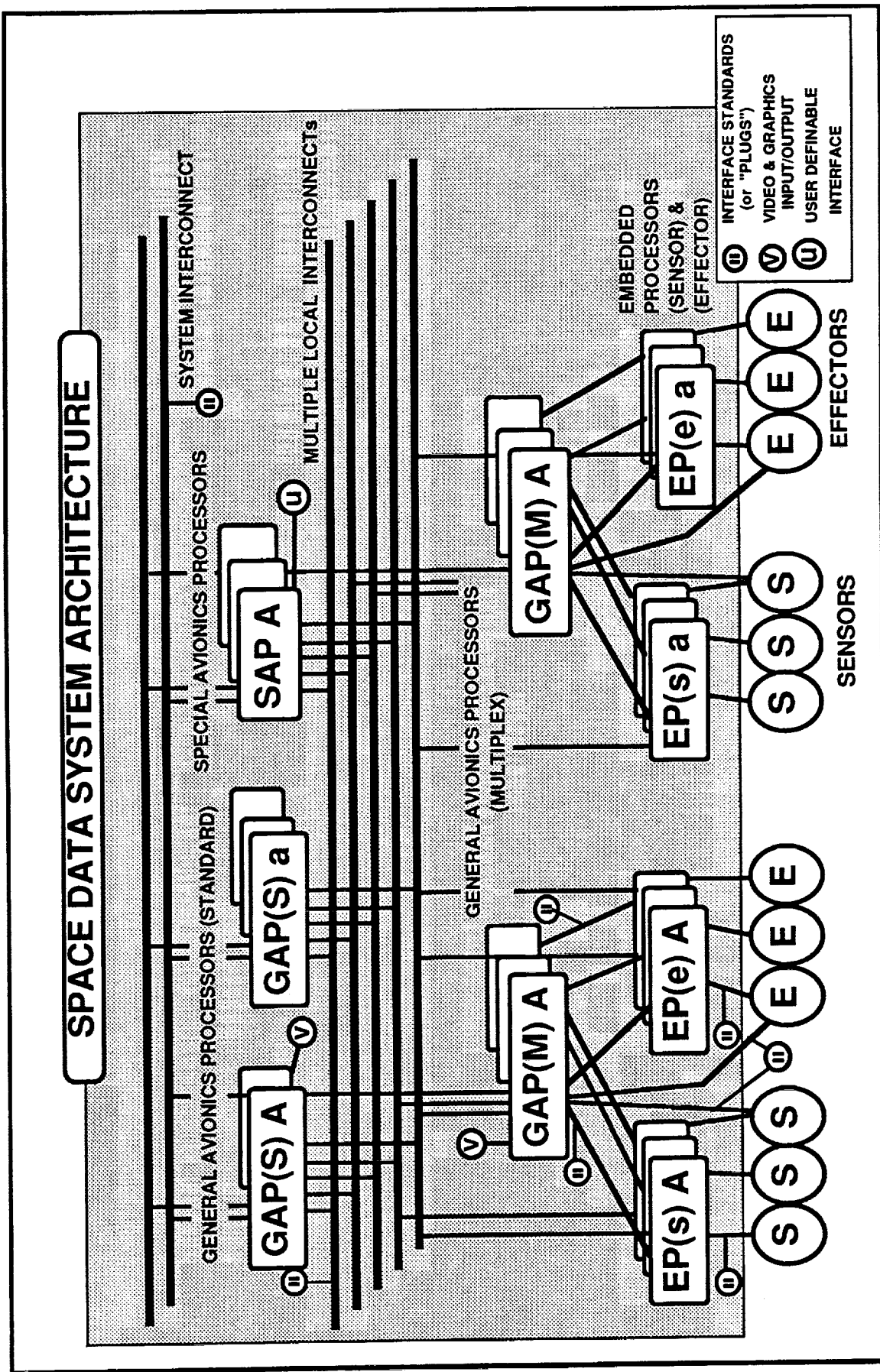
Figure 5-5. Generic Processing External Hardware Architecture and Interfaces for a Space Generic Open Avionics Architecture

5.2.1.2.1 GAP Architecture

GAPs represent general purpose data processors. A GAP, if required, shall [1] be one of two forms: one for standard general purpose use [GAP(S)] and one for multiplexing and demultiplexing signals [GAP(M)]. Typically, GAP devices are used where slow response times (such as on the order of seconds to tens of seconds) are required. An example of a compliant implementation of GAP(S) processors is the Standard Data Processor in the Space Station Freedom program and the General Purpose Processing Element in the F-22 program. An example of a compliant implementation of the GAP(M) is the Multiplexer-DeMultiplexer processor in the Space Station program.

5.2.1.2.2 SAP Architecture

SAPs if required, shall [1] provide the special purpose processing which is usually needed in high power embedded computers and may be implemented by devices such as vector or associative processors, massively parallel data processors, or arithmetic coprocessors. Typically, SAP devices are used where response times (such as on the order of hundreds of milliseconds to a second) significantly faster than in a GAP are required. Examples include the associative and vector processors used in the F-22 program.

5.2.1.2.3 EP Architecture

Within each sensor or effector, this architecture allows, but does not require, the placement of processors embedded in the sensor or effector unit. EPs if required, shall [1] be one of two forms: one for effector processing [EP(e)] and one for sensor processing [EP(s)]. EPs shall [2] provide the very high speed processing necessary to manipulate and convert analog data to digital data while performing some preprocessing on it to reduce the data rate to a more acceptable level for linkage back to the GAP(M). Typically, EP devices are used where very fast response times (such as on the order of milliseconds or less) are required. Where the data rate with the sensor or effector is acceptable to the GAP(M) and no other pre-processing is required, direct interface to the GAP(M) may be used. Sensors and effectors interface to the EP devices either through local communication interfaces or through direct links.

5.2.1.2.4 Lower Level Interface Standards

Lower level interface standards shall [1] be selected for implementing system interconnects, local interconnects, GAP to EP direct links, GAP to S direct links, GAP to E direct links, EP to

S direct links, and EP to E direct links. User definable interfaces shall [2] be provided for the SAPs. Lower level video and graphics interface standards shall [3] be selected to define implementations for connecting the GAP devices to humans for development, operation and maintenance of the systems.

5.2.1.3 General Avionics Processor Internal Hardware Architecture

The requirements for general purpose processing elements in a vehicle shall [1] be defined as shown in the GAP architecture presented in Figure 5-6. The generic hardware elements shown in the figure comprise the basic, generic hardware modular elements in the SGOAA. The processor may be configured as a GAP(S), GAP(M), EP(s) or EP(e) depending on the set of functions required by a specific application. The SAP is a special purpose case and may require functions not included in the generic processor function set such as vector or parallel processing.

5.2.1.3.1 GAP Function Set

The GAP function set is a shopping list of modular functions which can be used to build the needed configuration. Each module shown provides a specific independently procurable service. Additional unique service functions may be added by defining additional modules. The actual implementation in hardware is interface standard, technology and detailed design dependent. System performance requirements for hardware modular elements shall [1] be a primary consideration in module selection to perform a specific function. System error processing and fault treatment requirements for hardware modular element BITE shall [2] also be considered in hardware modular element selection. Specific hardware interfaces that shall [3] be defined by lower level standards are shown in Figure 5-6.

5.2.1.3.2 Internal Interconnect Interface Standards

Internal interconnect interface standards shall [1] be imposed to provide modularity with the capability for technology upgrades and multiple vendor sources of processing functions modules. Although only one internal interconnect bus is shown for the backplane in Figure 5-6, the actual bus implementation may consist of multiple buses depending upon the specific application. Possible buses include data, time, test, and local memory. Multiple standards exist for all of these bus types.

General Avionics Processor (S or M)

System Interconnect Proc
- Resource Consumption
- Loading
- Interface Standards
- Data Distribution Function

D I s c r e t e U / F

Application Processing
- Mission Application Perf.
- Application Program I / F
- Resource Isolation
- Processing/Logical Stds

Local Interconnect Proc
- Resource Consumption
- Loading
- Interface Standards
- Data Acquisition and Control Function

Backplane "Growth"

Internal Interconnect Standards

Test and Checkout (T&C)
- Special Purpose Maintenance Routines and Hardware which Interfere with Normal Processing

Auxiliary Memory Storage
- Mass / High Speed Memory for Special Needs

Other Processor Elements
- Vector, Associative, Massively Parallel, Neural, etc. Processors

Optional Functional Growth
- Optional Functional Growth-Specific Hardware and Software (e.g., time generator)

Video / Graphics
- Video and Graphics Specific Hardware and Software

I / O Processing
- Specialized I /O Processing Hardware and Software

Boundary=External Environment Interface

Local Inter-Connect Standards

Optional Functional Interface Standards

Timing Bus Interface Standards

Video Monitor Interface Standards

Discrete, Analog,

Serial, Parallel, Audio, etc. Interface Standards

T&C System Interface Standards

Memory Bus Interface Standards (e.g., IDE, SCSI, etc.)

System Inter-connect Standards

Figure 5-6. Generic Processing Internal Hardware Architecture

5-13

5.2.1.3.3 Lower Level Interface Standards

Lower level interface standards as illustrated in Figure 5-6 shall [1] be selected for system interconnect, test and checkout system, mass memory, timing bus, discrete data, analog data, serial data, parallel data, local interconnect, video/graphics, audio and optional functional growth interfaces. For example, to implement the functions of the basic GAP(S) would require implementation of the system interconnect processing, application processing and local communications (e.g., local interconnect and I/O) processing functions of the GAP Hardware Architecture shown in Figure 5-6. A internal interconnect bus standard such as Future Bus Plus (FB+), VME or Pi Bus would be imposed as the backplane data bus standard. The backplane bus standard used in a specific architecture implementation might consist of one or more specific buses; separate buses are permitted for uses such as test and maintenance.

5.2.2 CLASS 2 - HARDWARE-TO-OPERATING SYSTEM EXTENSION SOFTWARE DIRECT INTERFACE REQUIREMENTS

Hardware to operating system extension software interfaces are shown in Figure 5-7. These interfaces shall [1] consist of the interfaces from the operating system extension, low level software or other software performing the same function (such as drivers in the OS, data system manager, etc.) to the hardware instruction set architecture (ISA) and register usage. With regard to the model, these interfaces are internal to each processing element. The hardware elements are grayed out to show that these elements are a repeat of the previous figure; the black elements represent the new capabilities and interfaces added by this interface class. This class shall [2] define the interfaces for low level software drivers that interact with the hardware for each of the processor types (EPs, SAPs, and GAPs). All the drivers for all processor types shall [3] be contained in a SDSS sub-architecture.

5.2.2.1 Error Processing

All types of error processing on data transmissions for flight or safety critical functions through the class 2 interface shall [1] be allowed except those employing retransmission. For those mission critical or service functions that have no hard deadline requirements, error processing employing retransmission shall [2] be allowed.

Application Platform Hardware to Service Drivers

Software

- Data Base Manager
- Input/Output Data Services Manager
- Data System Manager
- Network Services Manager
- Operating System

- Normal-ization
- Specialized Processing
- Comm Interface
- I/O Formating
- Execution Control

- BIT
- Hardware Handler
- Comm Interface
- Execution Control

HW-SW Interfaces

- GAP-DRVRs Interface
- SAP-DRVRs Interface
- EP-DRVRs Interface

Hardware

GAP
- System Interconnect Processing
- Application Processing
- Local Inter-Connect Processing
- Option(s)

SAP
- Controller
- Filtering
- Specialized Processor
- System Interconnect Processing
- Local Inter-connect Processing

EP
- BIT
- Micro-Controller
- Hardware Handlers
- Local Interconnect Processing

LOCAL INTERCONNECT

SYSTEM INTERCONNECT

⑪ = Interface Standard

Figure 5-7. Class 2 Hardware-to-System Software Direct Interfaces

5.2.2.2 System Services Software

The system services software in the SDSS for the GAP shall [1] be organized into five categories. The categories shall [2] be the Data System Manager, Data Base Manager, Input/Output Data Services Manager, Operating System, and Network Services Manager. (See section 5.3 for interface service requirements.) The software drivers for the SAP shall [3] be organized into four categories: I/O)formatting, normalization, specialized processing interfaces, and local communications interfaces. The software drivers for the EP shall [4] be organized into four categories: built-in-test (BIT), hardware handler interfaces, local communications interfaces and microprocessor execution control.

5.2.2.3 Hardware/Operating System Extension Interfaces

The hardware/operating system extension interfaces needed for the hardware to be accessed by low level software such as drivers shall [1] be defined as shown in Figure 5-8. The interfaces are shown in black and labeled, and everything else has been grayed out to highlight items of interest.

5.2.3 CLASS 3 - OPERATING SYSTEM SERVICES SOFTWARE-TO-SOFTWARE (LOCAL) DIRECT INTERFACE REQUIREMENTS

Operating system services software to other local software direct interfaces shall [1] be defined as the operating system interfaces shown in Figures 5-9. This definition consists of the I/O handler calling conventions and context switch conversions between the system software drivers on one processing element interfacing with one or more system software services to provide for local information exchange. Class 2 provided the software drivers to isolate the hardware, Class 3 provides the remainder of the direct operating system interfaces to local software services needed to operate the computer system.

5.2.3.1 Local Software Service Grouping

All local software services shall [1] be grouped into the Data System Services (DSS) sub-architecture and shall consist of the Data System Manager, Data Base Manager, Input/Output Data Services Manager, Operating System, and Network Services Manager. Class 3 shall [2] provide the direct interfaces between the operating system services to other local data system services and applications for effective local interprocess communications and support. These interfaces are direct interfaces because they enable operating system service code to interact with software service code in other local entities. Although the

Figure 5-8. GAP to Hardware Drivers
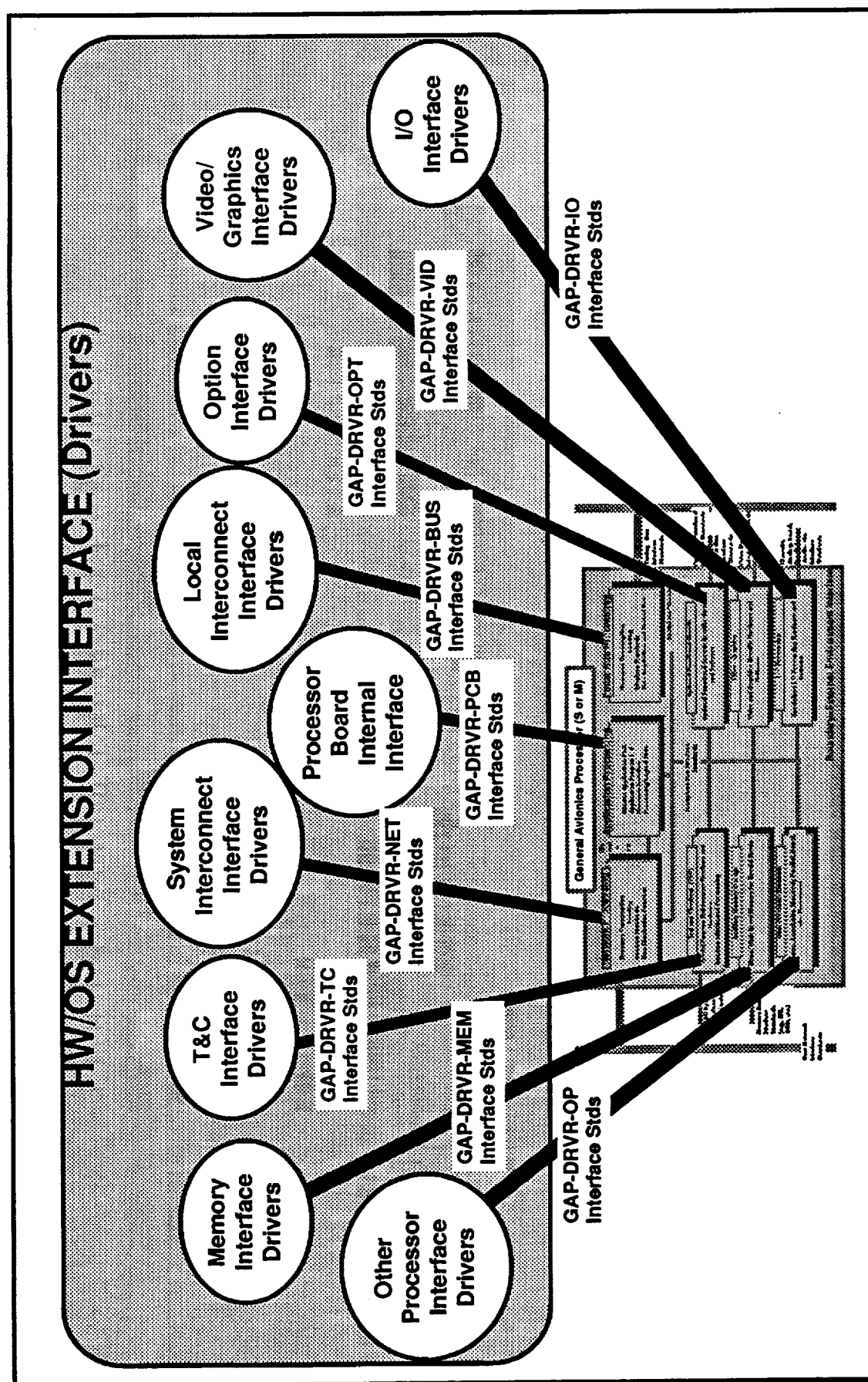
Operating System to Other Code
(i.e., Services or Applications)

⊞ = Interface Standard
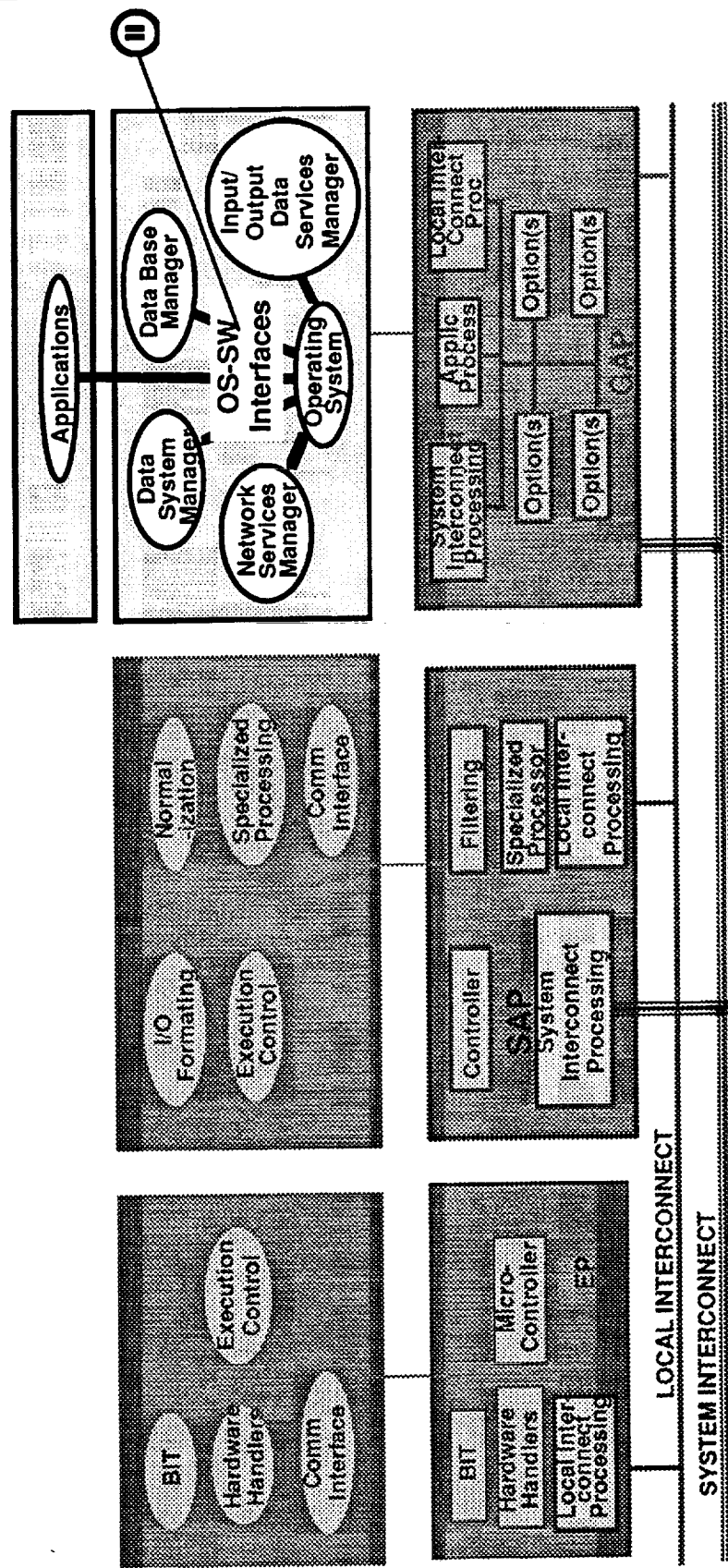
Figure 5-9. Class 3 System Software-to-Software Direct Interfaces

5-18

operating system services are a subset of the DSS, they shall [3] also provide direct low level operating system service access not provided by the higher level DSS interface for those users requiring this type of interface. Class 3 interfaces shall [3] meet derived requirements based on the need of an application to support users.

5.2.3.2 Class 3 Flight, Safety and Mission Critical Interfaces

For class 3 interfaces of flight, safety or mission critical functions with hard deadlines to either the Data System Manager or to Device Drivers, all types of error processing on data transmissions through the class 3 interface shall [1] be allowed except those employing retransmission. For those mission critical or service functions that have no hard deadline requirements, error processing employing retransmission shall [2] be allowed. For class 3 interface to applications, no error processing across the interface shall [3] be allowed (that is, the data transmission itself is assumed to be error free).

5.2.3.3 Class 3 Operating System Interfaces

The operating system-to-system service software and applications software interfaces shall [1] be defined as shown in Figure 5-10. The interfaces are shown in black and labeled. Note that there are three possible types of interfaces: upward between the operating system services to any software application, upward to other data system services, and downward to the system extension software such as drivers within the operating system. Their grouping into class 3 facilitates design of operating systems and all interfaces needed to insure effective operating system performance.

5.2.4 CLASS 4 - DATA SYSTEM SERVICES SOFTWARE-TO-DATA SYSTEM SERVICES SOFTWARE LOGICAL INTERFACE REQUIREMENTS

Data system services software to data system services software interfaces shall [1] be defined as shown in Figure 5-11. This is the peer to peer interface of data system services software in one processing element (GAP, SAP or EP) interfacing with the system software in the same processing element or remotely to an external processing element to coordinate operations in a distributed environment. Since Classes 1 to 3 isolated the hardware and software services in each processor, Class 4 shall [2] provide the interface capability for services in one processor to interact with services in the same or another processor. Class 4 interfaces shall [3] meet derived requirements based on the need of an application to support users in a multi-processing environment.

Figure 5-10. Operating System Interfaces

Services to Other Services Data Transfers
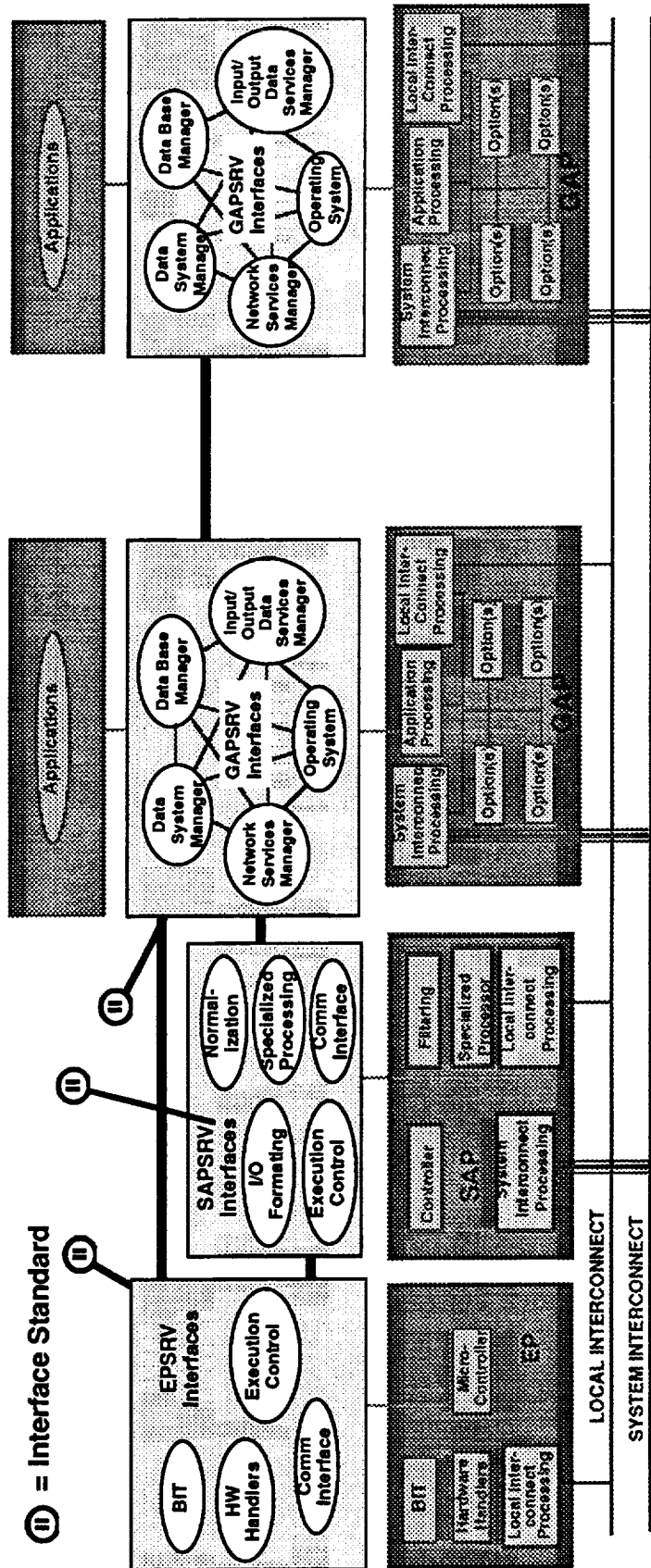
Figure 5-11. Class 4 System Software-to-System Software Logical Interfaces

5.2.4.1 Class 4 Critical Function Error Processing

For flight critical functions, error processing shall [1] not be allowed on data transmissions across the class 4 interface. For safety critical, mission critical or service functions, error processing not employing retransmission shall [2] be allowed.

5.2.4.2 Class 4 Data System Services Interfaces

The DSS interfaces needed to support local operations and logical access to other GAP data system services shall [1] be identified as shown in Figure 5-12. The black-line interfaces are the primary interfaces between the local services. Local services and remote services shall [2] have a common logical architecture. For distributed processing systems, a circular interface between each service entity and itself shall [3] be defined as shown in Figure 5-12, since each service must be able to communicate with remote versions of itself in other nodes. Remote interfaces to the special avionics processor and the embedded processor services shall [4] also be defined and specified.

5.2.5 CLASS 5 - DATA SYSTEM SERVICES SOFTWARE-TO-APPLICATIONS SOFTWARE (LOCAL) DIRECT INTERFACE REQUIREMENTS

DSS software to applications software interfaces shall [1] be defined as shown in Figure 5-13. This is the direct interface within a processing element between the application software and the DSS software (language bindings/specification) to allow provision of needed services. Since Classes 1 to 4 isolated the hardware and software services in all the processors, Class 5 shall [2] provide the interface capability for services in any processor to interact with an application executing in the processor. Class 5 interfaces shall [3] meet derived requirements based on the need of an application to support users in a multi-processing environment.

5.2.5.1 Class 5 Error Processing

Error processing on data transmissions across the class 5 interface shall [1] not be allowed. Transfer of error processing results over the class 5 interface to Onboard Health Management processing shall [2] be allowed.
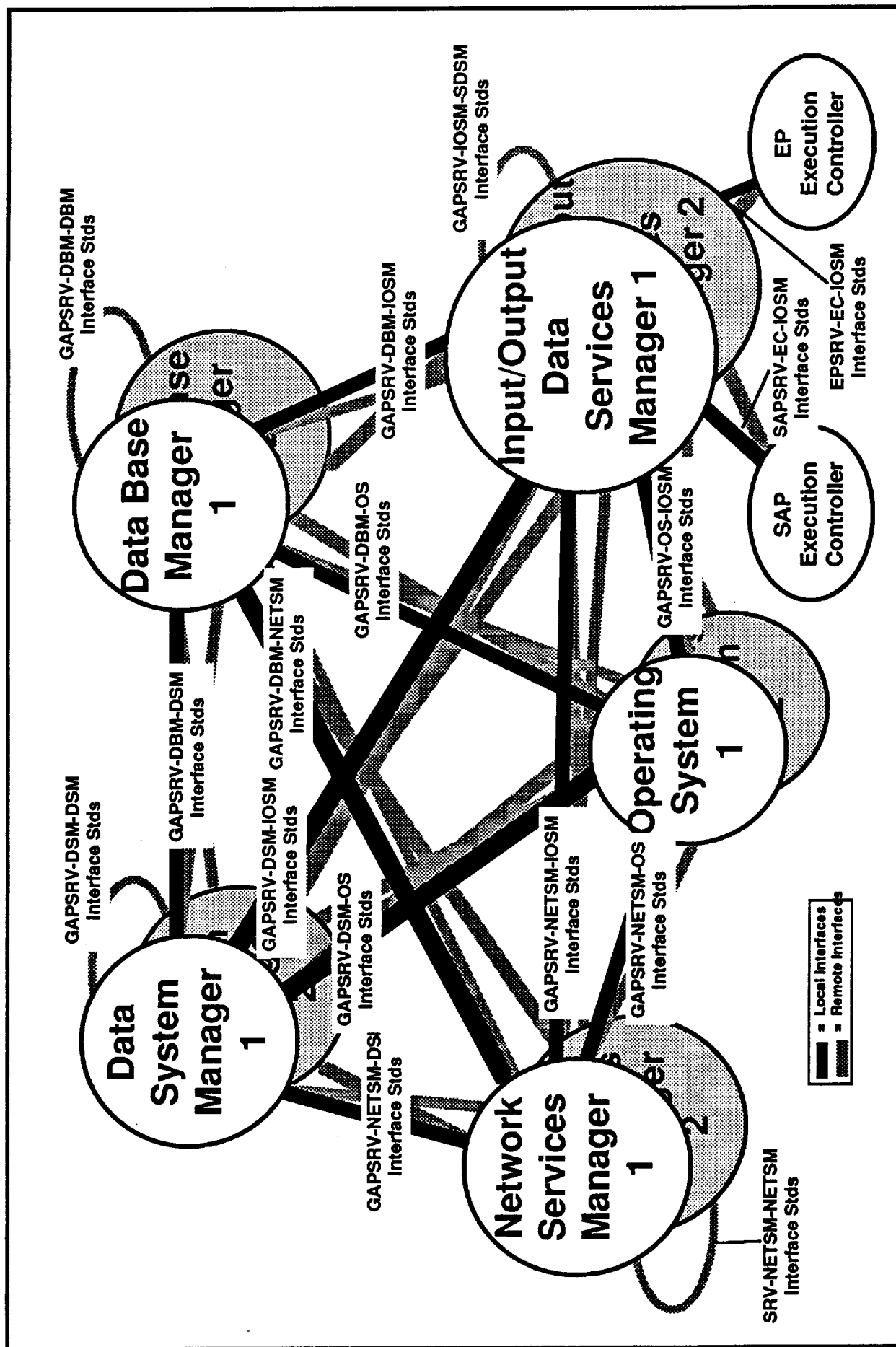
Figure 5-12. SDSS Services to Other or Remote Services

Figure 5-13. Class 5 System Software-to-Applications Software Direct Interfaces

5.2.5.2 Services to Applications Interfaces

The DSS to applications interfaces shall [1] be defined as shown in Figure 5-14. The applicable interfaces are shown in black and labeled, and everything else has been grayed out to highlight items of interest. There shall [2] be a standard access interface to the data system services, which is a function of the service and independent of any one application. The Input/Output Data Services manager shall [3] be capable of providing access to other services as well as directly to the application or sensor providing the source of data. The data system manager shall [4] be capable of providing control interfaces to other control subsystems.

5.2.6 CLASS 6 - APPLICATIONS SOFTWARE-TO-APPLICATIONS SOFTWARE (LOGICAL) INTERFACE REQUIREMENTS

Applications software to applications software interfaces shall [1] be defined as shown in Figure 5-15. This shall [2] be a peer to peer information exchange and coordination interface between application software modules. Applications shall [3] not communicate directly. All application to application software communication shall [4] be implemented by use of system services software. All communication shall [5] be through a Class 5 standard interface to System Services to provide the direct communications path between applications. This interface may be between applications within a processing element or between applications in separate processing elements. The grayed out parts of the figure represent the material covered in Classes 1 to 5, the black parts of the figure are the new interface definitions added in Class 6. Since Classes 1 to 5 isolated the hardware, software services and applications in any processor, Class 6 shall [6] provide the interface capability for an application in any processor to interact with another application executing in any processor. Class 6 interfaces shall [7] meet user and derived requirements based on the need of multiple applications to support users in a multi-processing environment.
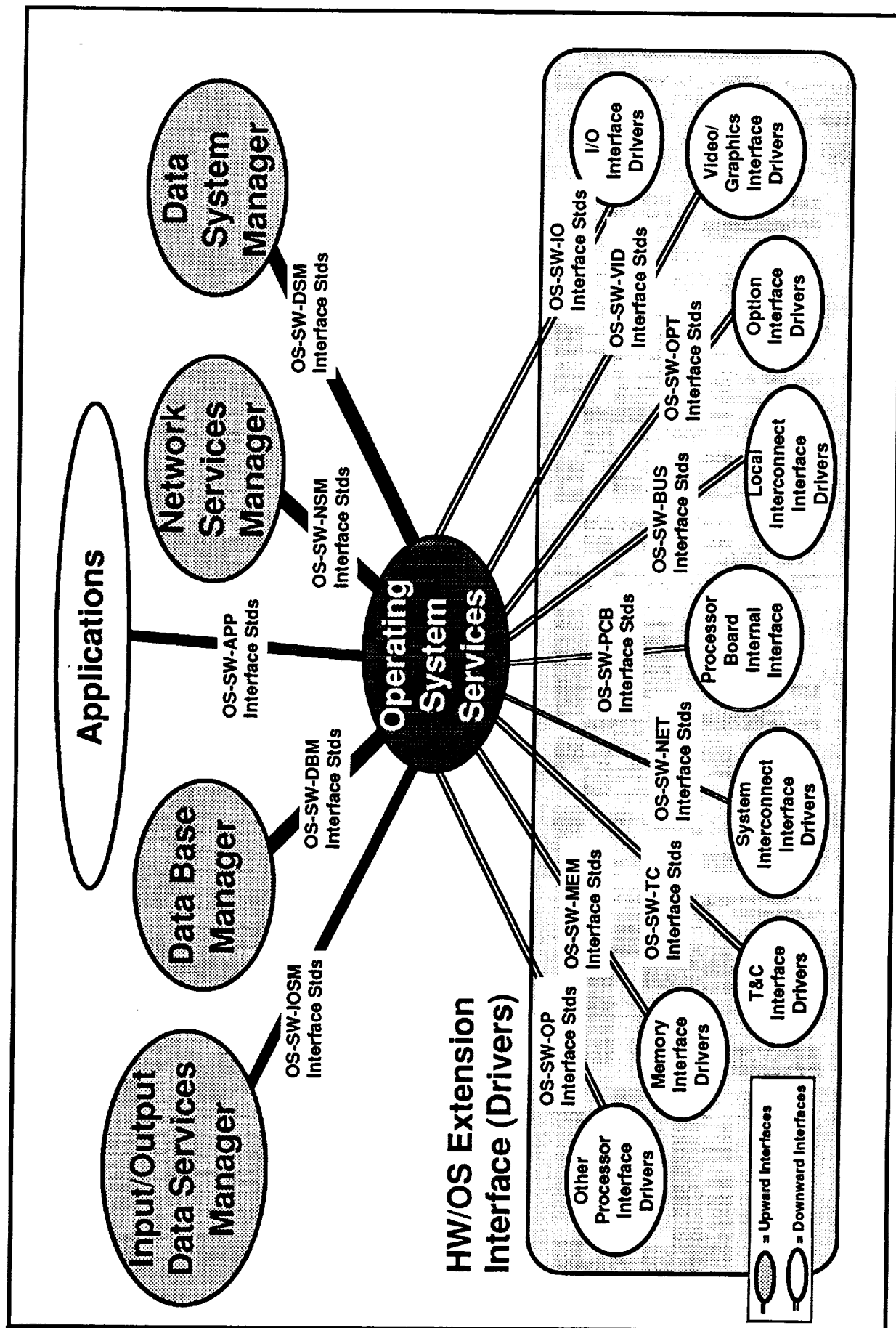
5.2.6.1 Class 6 Error Processing

Error processing on data transmissions across the class 6 interface shall [1] not be allowed. Transfer of data between Onboard Health Management entities shall [2] be allowed.

5.2.6.2 Applications to Applications Interfaces

Applications to Applications interfaces may also include interfaces between applications in two different systems or vehicles. System A applications software to system B applications
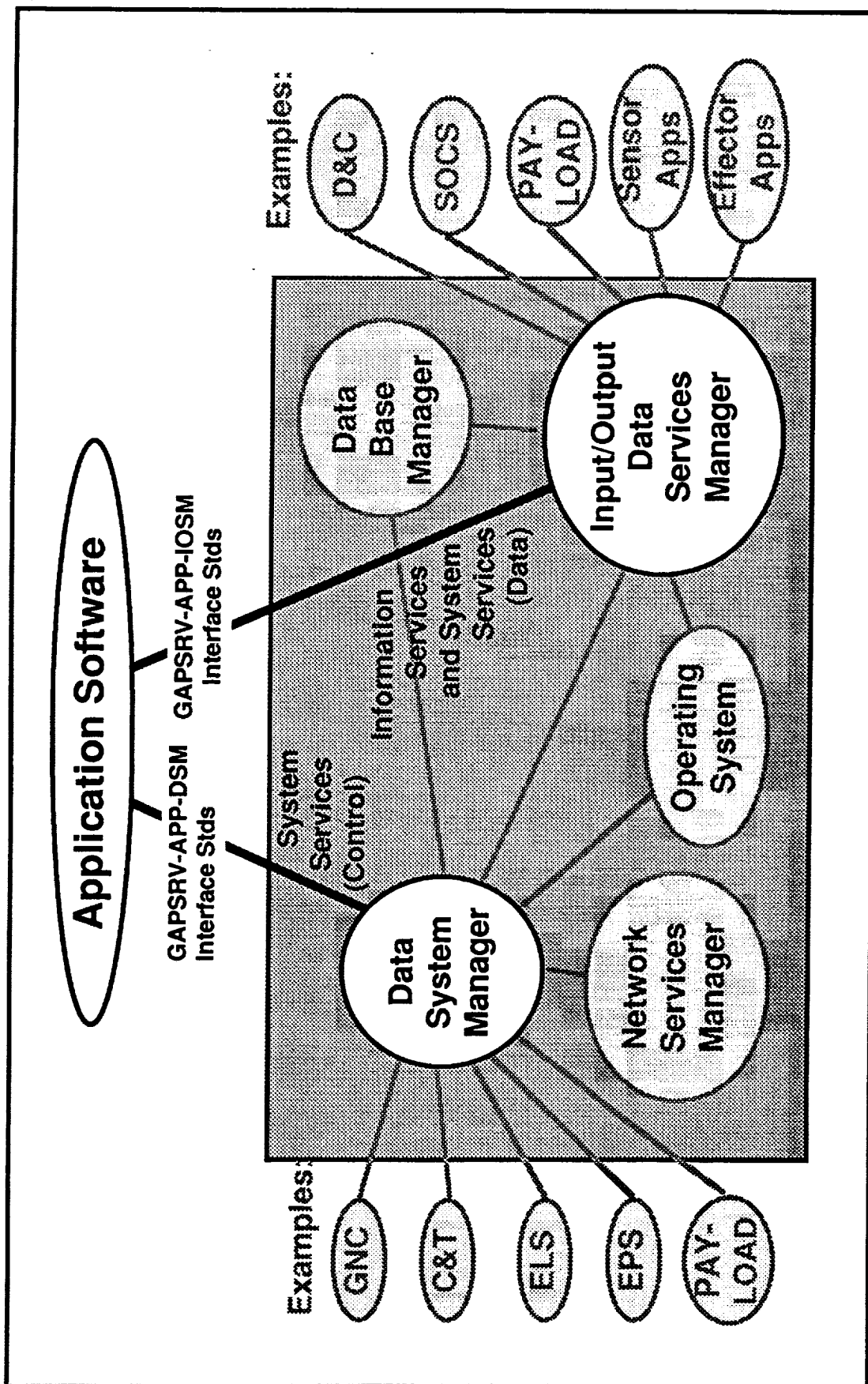
Figure 5-14. Services to Applications Interfaces
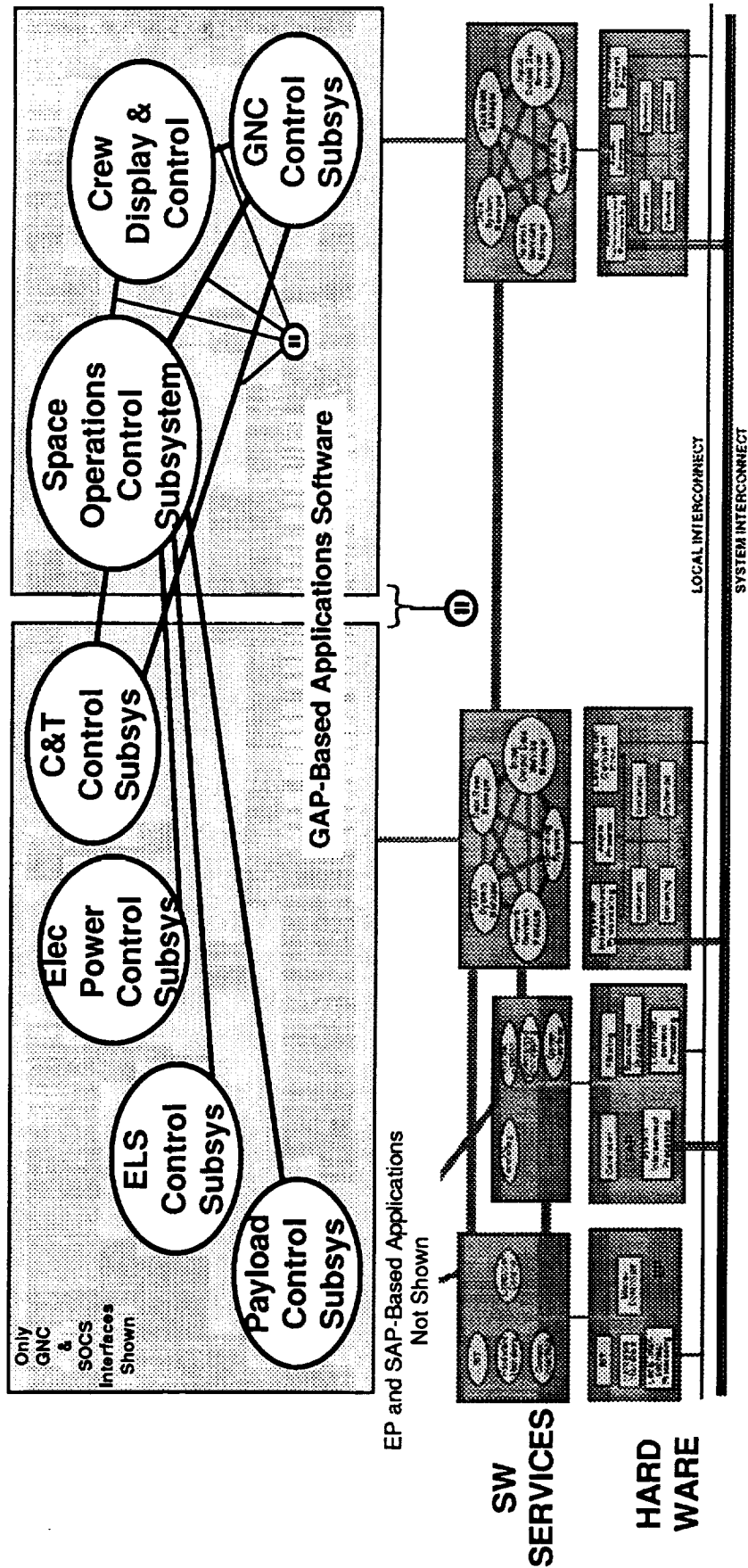
Figure 5-15. Class 6: Applications Software-to-Applications Software Logical Interfaces

software interfaces shall [1] be defined as shown in Figure 5-16. The grayed out parts of the figure represent the material covered in Classes 1 to 6 (within one system), the black parts of the figure are the unique interfaces that are provided by Class 6 for inter-system interfacing. Since Classes 1 to 5 isolated the hardware, software services and applications in any system, Class 6 shall [2] provide the interface capability for an application in one system to interact with an application executing in another system. Class 6 interfaces shall [3] meet user and derived requirements based on the need of multiple applications to support users in a multi-system environment. Class 6 interfaces shall [4] be defined to meet the overall mission and operational control requirements across multiple facilities and vehicles.

5.3 DATA SYSTEM SERVICE ARCHITECTURAL REQUIREMENTS

The DSS architecture shall [1] include capabilities drawn from up to five categories of services: the Data System Manager, Data Base Manager, Input/Output Data Services Manager, Operating System, and Network Services Manager, as shown in Figure 5-17. Interfaces from external entities to the DSS shall [2] be as shown. Control of the data system resources shall [3] flow through the Data System Manager (DSM) to insure coordination of the system configuration at all points for reliability. Data shall [4] flow through the Input/Output Data Services Manager (IOSM). Crew display and control (D&C) shall [5] be capable of operating through at least the IOSM and the DSM to insure at least one normal and one alternative path for direct low level system command and control by the crew. Similarly, operations control shall [6] be capable of operating through at least the IOSM and the DSM to insure at least one normal and one alternative path for direct low level system control by the ground or mission control. Access by applications will be as required by the system requirements documents.

The DSS architecture shall [7] provide options for at least the services as organized and shown in Figure 5-18. Implementation requirements for such services will depend on the system requirements documents.

5.3.1 INPUT/OUTPUT DATA SERVICES MANAGEMENT

The Input/Output Data Services Manager shall [1] provide all interface to the system users for data processing and data communication services. Services to be provided to the users shall [2] be derived directly from user requirements. The input/output data services management shall [3] include at least requirements for standard services data acquisition, standard services data distribution and reports generation.

System-to-System Applications Logical Data Transfers

Figure 5-16. Class 6 System A Software-to-System B Software Logical Interfaces

Figure 5-17. Data System Services Architectural Interface Elements

INPUT/OUTPUT DATA SERVICES MANAGER

- **INPUT/OUTPUT SERVICES DATA ACQUISITION CONTROLLER**
  - Data Bus Services
  - Sensor and Effector Input/Output
  - Sensor Pre-Processing Services
  - Distributed Data Link & Write (to DB)
  - Journal Manager
- **INPUT/OUTPUT SERVICES DATA DISTRIBUTION**
  - Distributed Data Link and Read (to DB)
  - Caution & Warning Processing
  - Telemetry Processing
  - History Processing
- **REPORTS GENERATOR**
  - Tables
  - Forms
  - Outputs

DATA SYSTEM MANAGER

- **CONFIGURATION MANAGER**
  - Uploaded SW Tables Change Mgt
  - Reconfigure HW & SW
  - Maintain System Config
- **TIMING SERVICE CONTROLLER**
  - Monitor Timing Service
  - Automatic Timing Reconfiguration
  - Manual Timing Reconfig
  - Update Timing
  - Resynchronize Timing
- **DATA SYSTEM INIT., STARTUP AND RECONFIG**
  - Identify SW To Be Loaded
  - Load and Initialize SW
  - Terminate Software
  - Process Initial and Reload Requests
- **DSM HEALTH, STATUS AND FDIR CONTROLLER**
  - Collect Health Status and Failure Data
  - Process Health Status and Failure Data
  - Automatic Reconfiguration
  - Manual Reconfiguration
  - Update History Data Base

OPERATING SYSTEM

- **OS KERNAL**
  - Process Mgt & Control
  - Initialization and Configuration Mgt
  - I/O Management
  - Memory Mgt
  - CPU Management
  - Utility Services
  - Privacy & Security Mgt
- **ADA RTE**
  - ADA Compiler Support
  - ADA/Non-ADA Mixed Environment
  - ADA Real-time POSIX Compliant Environment
- **OS/RTE EXTENSIONS**
  - Real-time Applications
  - Task Control & Communications
  - ADA Multi-Program Mgt
  - Inter-Process Communication
  - Internal Bus Management
  - OS/RTE Initialization and Self Test
  - Precision Time Distribution
- **Non-Standard Processor Services**

DATA BASE MANAGER

- **FILE SERVICE CONTROLLER**
  - Sequential File Srv
  - Structured File Services
  - Distributed File Services
  - Resource Management (In mass store)
- **DISTRIBUTED FILE TRANSFER SERVICE CONTROLLER**
  - Internal System Node Transfers (In Each Node)
  - Recording Ctrl
- **FILE TRANSFER, ACCESS AND MANAGEMENT CONTROLLER**
  - External Node Transfers
  - Virtual/real file mapping
  - Ground archives (In mass store)

NETWORK SERVICES MANAGER

- **NETWORK SERVICE CONTROLLER**
  - Network Command Verification
  - Network Stack Controller
  - Network Queue Management
  - Stack
- **NETWORK MANAGER**
  - Network Coordinator
  - Network Status Directory
  - Network Fault Detection
  - Stack Layer Management
  - Network Security Mgt
  - Network Performance Status
- **REMOTE OPERATOR**
- **NETWORK DIRECTORY SERVICE CONTROLLER**
  - Directory User Agent
  - Directory System Agent
  - Directory Information Base
  - Directory Information Tree
- **NETWORK ASSOCIATION CONTROLLER**

Figure 5-18. Interface Service Elements

5.3.2 DATA SYSTEM MANAGEMENT

The Data System Manager shall [1] provide the housekeeping and control services for the SDSS. Command and control service requirements shall [2] be derived directly from user needs. Data system management shall [3] include at least requirements for configuration management, timing service control, initialization startup and reconfiguration, error processing, error recovery, fault treatment and reporting of health status to onboard health m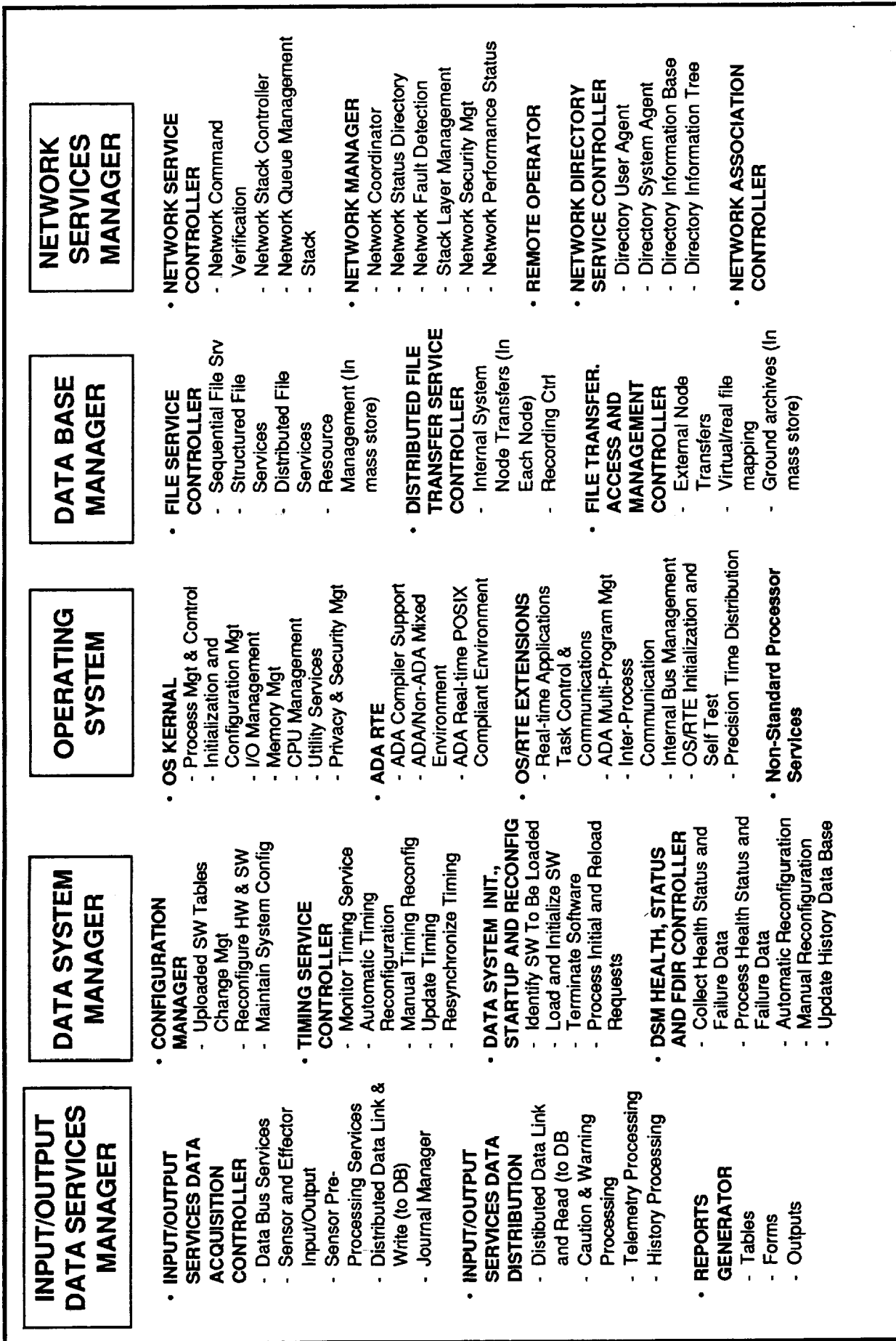anagement. The DSM shall [4] execute under the Operating System. There is a command and control interface to the crew and to the SOCS. Command and control service requirements are derived directly from user needs.

5.3.3 NETWORK SERVICES MANAGEMENT

The NSM shall [1] provide for peer-to-peer communication between applications on distributed processing elements communicating over the SDSS system interconnect which require use of network communications between applications in distributed processing environments. The network services management shall [2] include at least requirements for network services, network management, remote operation, network directory service, and network association control.

5.3.4 DATA BASE MANAGEMENT

This entity shall [1] provide services to the SDSS subsystems and application users for the management of structured data files, file transfers and file redundancy management. The data base management shall [2] include at least requirements for file services, distributed file transfer services, file transfer access and management, and node directory. All communication with and requests for services from the DBM shall [3] be through the IOSM.

5.3.5 OPERATING SYSTEM

The OS shall [1] provide the layer of SDSS software that isolates other services as well as application software from the data processing hardware element. The OS shall [2] provide management, allocation, and deallocation of the processor, memory, timing and I/O processing resources for application and service software and hardware that is independent of the mission. The operating system shall [3] offer at least open standard OS services such as an OS kernel and/or a run time environment (RTE) and OS/RTE extensions. Resource allocation and control that is mission dependent shall [4] be treated as an application.

A bare machine user may interface directly with the Run Time Environment (RTE).

6. NOTES

(This section contains information that may be helpful, but is not mandatory)

6.1 AVIONICS SYSTEM NOTES

6.1.1 AVIONICS GENERAL

Avionics provide for information acquisition, transmission, and storage of analog or digital signals and include the sensors, intra-platform communications, processing hardware, software and subsystems, data storage, human-machine interface subsystems, and response actuator controls used in the vehicle.

6.1.2 MODES

Modes govern how the system operates in response to human commands. Mission ready mode means the system has all elements working as specified or "green". Operationally ready mode means the system can function but can not accomplish a desired mission, for instance when an aircraft is configured for a reconnaissance mission but is needed for a bombing mission, or when a spacecraft is can be launched but has no payload installed. Degraded mode means the system is "soft broke", but can perform a subset of its required functions. An example is when an aircraft radio is not working so not all functions can be performed but the aircraft can still fly and drop bombs. Red-tagged mode means that the system cannot operate at all, for instance when an aircraft fuel system is polluted or a wheel is broken on the ground.

6.1.3 ARCHITECTURE INTERFACE MODEL

The Architecture Interface Model is summarized in Figures 5-3 and 6-1. Figure 5-3 presented the architecture reference model, and Figure 6-1 presents an overlay of the reference model on the generic avionics structure assembled in this standard. Both figures also show the relationships of this architecture interface model to the POSIX interfaces.

6.2 REQUIREMENTS NOTES

6.2.1 DATA PROCESSING SUBSYSTEM

Data processing subsystem requirements are inherited onto lower level subsystems. A data processing subsystem is setup and controlled by a runtime operating system.
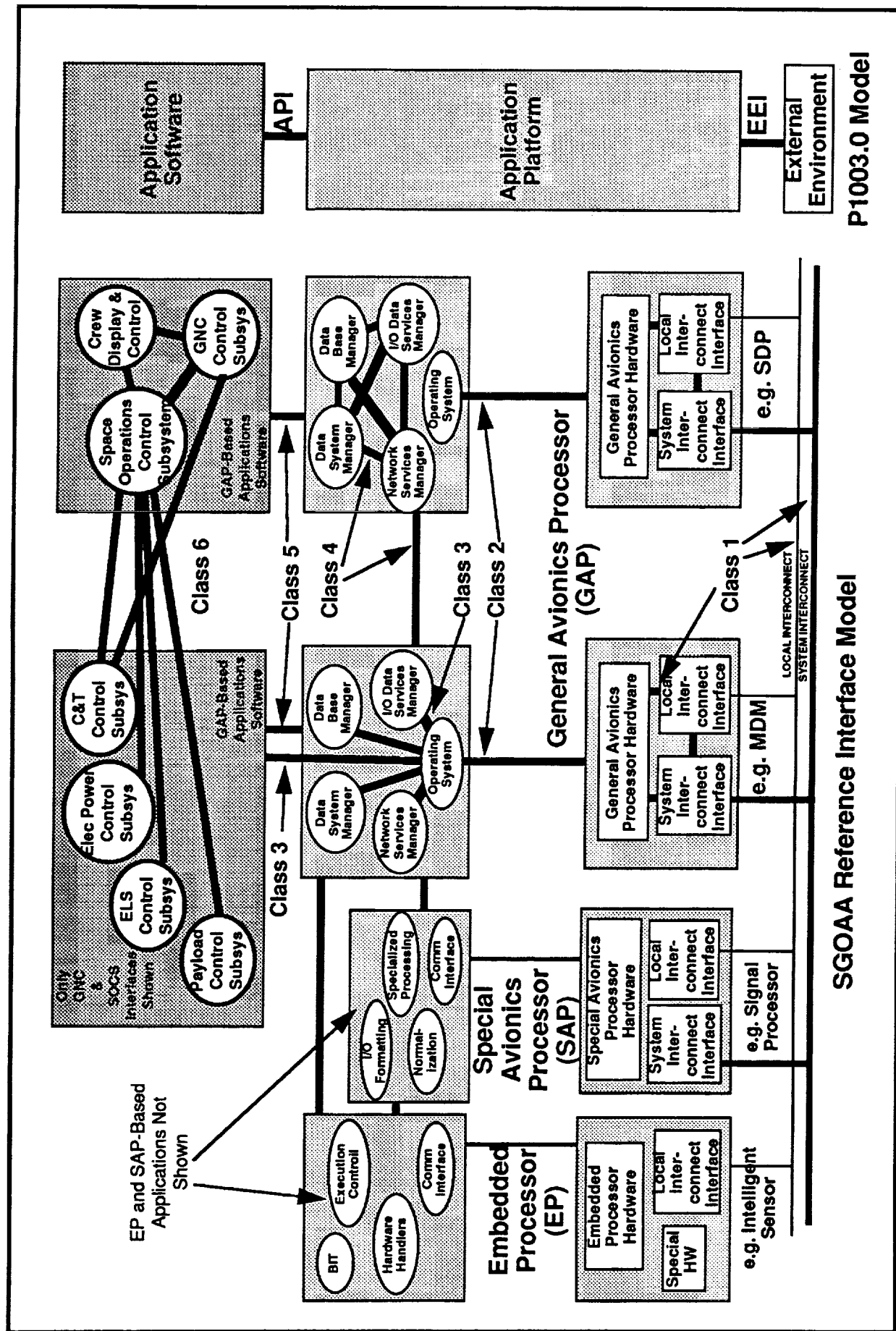
Figure 6-1. Generic Avionics Architecture Interface Model

6.2.2 INTERSYSTEM APPLICATIONS INTERFACE

Intersystem applications interface requirements address *logical* requirements of the user across the interface.

6.2.3 CONTROL SUBSYSTEM

Control subsystem requirements are inherited onto lower level control subsystems.

6.2.4 MODULAR ARCHITECTURE

Modular architecture requirements changes should not cause disproportional changes in the design, and design changes should be limited to one or a few design modules. Requirements changes should not affect the architecture of the system, unless the change is one for the architecture directly.

6.2.5 DIRECT INTERFACE

Direct interface requirements are normally a design issue unless the physical implementation has implications for the logical use or need for data, only then should the direct implementation be specified as a requirement. For instance, a service such as a Reports Generator getting data from a Data Base Manager might not need to know the inter-network addressing of the Data Base Manager, but the Network Manager providing the data would need to know the routing requirements of the hardware services.

6.3 REQUIREMENTS CHARACTERISTICS DESIRED

6.3.1 ROBUSTNESS

Robustness must enable a system to operate in conditions not originally foreseen by the specification without catastrophic failures, without exhibiting behavior that disturbs the rest of the system, by failing (if necessary) in a "graceful" manner by terminating cleanly and safely.

6.3.2 SYSTEM SERVICES SOFTWARE

System services software must have common and standardized interfaces serving many applications.

6.3.3 SERVICE FUNCTIONS

Service functions are usually widely replicated in support of many control or data processing subsystems. This wide replication of functionality is a key determining characteristic in defining an individual process as a service in this methodology. Services are critical to system operation, not to mission or vehicle operation per se. An example of a service function is a Report Generator since many applications and control subsystems must generate reports; here, they call on the report generator service which knows how to look up the table defining the applications/control report, how to format the format for completion, how to find the data to fill the report fields with, and how to route the report for distribution based on a predefined distribution list. High level standard services are services such as timing, distributed data handling and fault tolerance, which may have different needs when viewed as a multi-processing system than when considered as a single processor system.

6.3.4 TAILORING

Tailoring of the SGOAA may result in subsets of requirements applicable to a mission or program, but the resulting system must retain architectural interface compatibility.

6.3.5 SYSTEM CHARACTERISTICS

System characteristics that determine the nature and requirements for a system hardware architecture are the number of processors, their type and topology, the speed and size of shared memory available, the local memory of each, the bandwidth and access to communications media, and the interfaces available for use by people, applications and platform software services in the hardware.

6.3.6 ONBOARD HEALTH MANAGEMENT

Onboard health management facilitates tradeoffs between requirements for and design of reliability, maintainability, error processing, and fault treatment. Compliant architectures should also facilitate defining requirements for and interactions between health management, logistics, supportability, and safety management.

6.4 ARCHITECTURAL CHARACTERISTICS DESIRED

6.4.1 SYSTEM SOFTWARE ARCHITECTURE

A system software architecture must describe the set of system functions performed by the applications software, and the structure of the platform software services that enable the applications software to perform their tasks. The functionality described by the system software architecture are the tasks which are required of the system to meet the needs of operational users.

6.4.2 APPLICATION PLATFORM

The application platform provides services at its interfaces that, as much as possible make the specific characteristics of the platform transparent to the application.

6.4.3 APPLICATION PROGRAM INTERFACE

The API is primarily in support of application portability, but system and application interoperability are also supported by the communications API.

6.4.4 ARCHITECTURE LOCATION INDEPENDENCE

Architecture location independence is desirable, meaning an architecture compliant with this standard should be independent of whether control functions are implemented onboard the vehicle or offboard the vehicle (e.g., in support control facilities).

6.4.5 FAULT TOLERANCE TRANSPARENCY

Fault tolerance transparency is desirable, meaning applications in an architecture compliant with this standard should not require knowledge of the redundancy of its platform or its direct interfaces.

6.4.6 ADAPTABLE REDUNDANCY

Adaptable redundancy is desirable, meaning that an architecture compliant with this standard should allow more than one configuration of the architecture to provide different levels of redundancy. This allows another level of commonality beyond that of hardware and software modules.

6.5 DIRECT AND LOGICAL INTERFACE NOTES

6.5.1 CLASS 2 DIRECT INTERFACE

The Class 2 Hardware-to-System Software Direct Interface drivers are (obviously) hardware dependent, but this enables the architecture to begin partitioning out of the hardware dependencies, which is a key in providing for technology upgradability in the future.

6.5.2 HEALTH MANAGEMENT INTERFACE

Note that interface drivers specifically defined for health monitoring are not required. Each required driver will collect all data associated with its hardware element and format it for conveyance to the appropriate operating system interfaces; if health monitoring capabilities have been implemented in the associated hardware, then this data will be collected along with all other data.

6.5.3 CLASS 4 LOGICAL INTERFACES

Class 4 System Software-to-System Software Logical Interfaces provide the interface capability for services in one processor to interact with services in the same or another processor. They are the heart of multi-processor capability needed in modern space avionics systems. EP services can interact with SAP and GAP services; SAP services can interact with GAP services; GAP services can interact with EP and SAP services and other GAP services. These interfaces are logical interfaces because the service originating data is interacting with the service that will use the data (i.e., that will transform the data into another form for a purpose).

6.5.4 CLASS 5 DIRECT INTERFACES

Class 5 System Software-to-Applications Software (Local) Direct Interfaces provide the capability for services in any processor to interact with an application executing in the processor. Applications can operate in any GAP, with potential partitioning of an application across multiple GAPs. Similarly, applications can operate in any SAP or any EP. These Class 5 interfaces are direct interfaces because the applications software code is interacting with the service software code.

6.5.5 CLASS 6 LOGICAL INTERFACES

The Class 6 Applications Software-to-Applications Software (Logical) Interfaces are logical interfaces because the application originating data is not directly interacting with applications that will use the data. Class 6 interfaces are also the interface for exchange of information between the space avionics system and another avionics system for overall command and control. This interface is at the mission level and may be an information exchange between the ground or between separate space vehicles.

Class 6 also provides the basic multi-system capability to meet multiple actual user requirements in multiple systems, facilities or vehicles. Applications can operate in any system's processor (e.g., the Mission Control Center GAP or workstation) to cooperate with applications in another system's processor (e.g., the Lunar Transfer Vehicle GAP).

6.6 IMPLEMENTATION CHARACTERISTICS

In implementation, tailoring of the generic architecture to the unique requirements of the mission and system application is critical to successful use of this architecture. Profiles need to be applied. Such usage must recognize the scaleability, recursiveness and interaction between target and development environments in order to take full advantage of the utility of this architecture.

6.6.1 ARCHITECTURE SCALEABILITY

The generic system architecture model can be scaled to apply to the size and definition of system being used in any type of hardware/software processing system. It is equally applicable to systems at the vehicle level, rack or black box level, module or board level, or chip level, as shown in Figure 6-2. In this figure, examples of a system interconnect, local interconnect and internal interconnect change as the scale of system application changes. The use of embedded processor, general avionics processor and special avionics processor also changes. While only intended as an example, this figure makes clear that when two more engineers are applying the this architecture to a specific project, mission or system, great care must be taken to insure all discussions reference the same level of "system".

6.6.2 ARCHITECTURE RECURSIVENESS

The generic architecture interface model can be recursively applied to different usages of layers (i.e., hardware, drivers, OS, etc.) between the SGOAA classes in the architecture. As
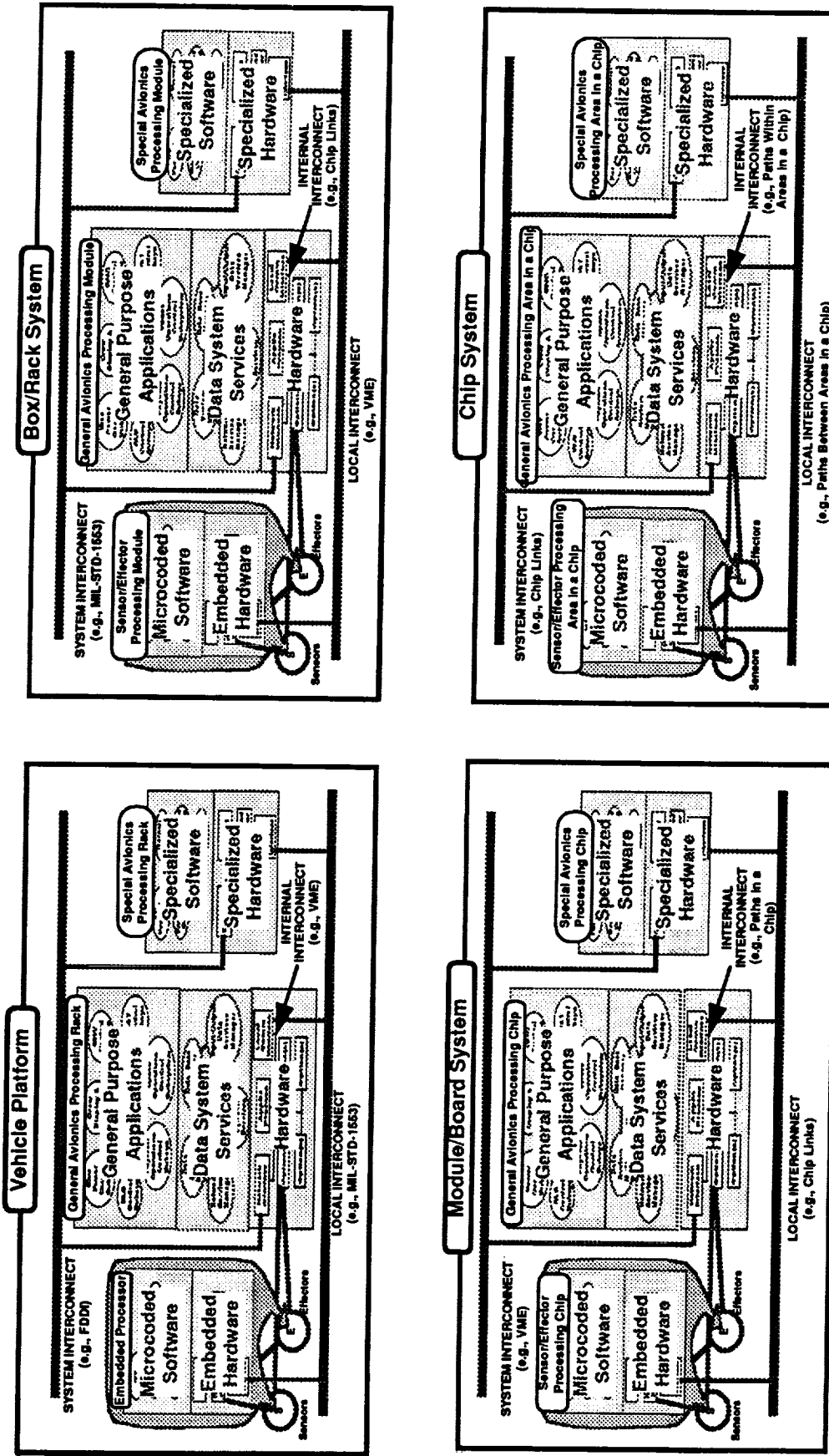
Figure 6-2. The Generic System Architecture Model Is Scaleable

shown in Figure 6-3, from an external view, hardware such as an ethernet board is a monolithic block. However, from within the block, ethernet "hardware" may consist of a microcosm of the entire interface model with board drivers, a OS kernel/RTE, some ethernet services and some ethernet processing applications all resident on the board. All of these microcosmic elements are transparent to an outside user passing through the interface.

6.6.3 ARCHITECTURE TARGET DEVELOPMENT

The architecture applies equally to any hardware/software processing system. In the example shown in Figure 6-4, it applies to a development environment, where development software such as a compiler is an application, which must have knowledge of the host, the target and the programming language being used. Within the development environment, there are services, OS elements and drivers. The target code is operated on by the development environment and transferred upon completion to the target hardware to execute. From the view of the target environment, this development environment is transparent.

6.7 TERMINOLOGY NOTES

In the space systems avionics arena, a data system is terminology used to refer to the set of operating system elements and supplementary or common services controlling processing resources in a host platform. This is similar to and includes the terminology system executive and distributed executive as used in PAVE PILLAR, global executive as used in parts of the F-22 Program, or common system services (e.g., an operating system) as used often in POSIX and other parts of the aircraft avionics arena. This standard differentiates between data system and data system services, in that a data system includes data system services, command processing, and other common capabilities (see Space Data System and Space Data System Services definitions in Section 3.1).
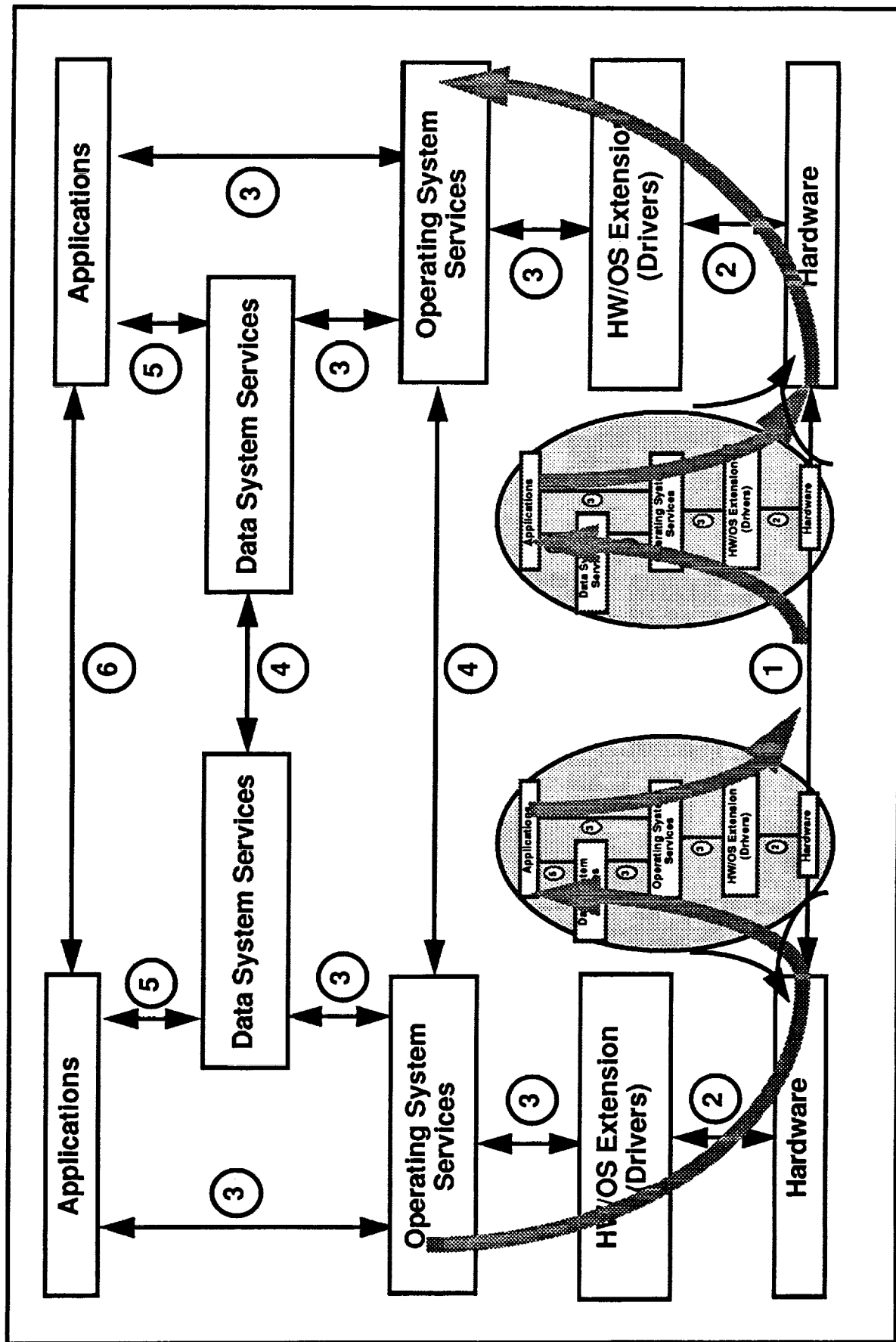
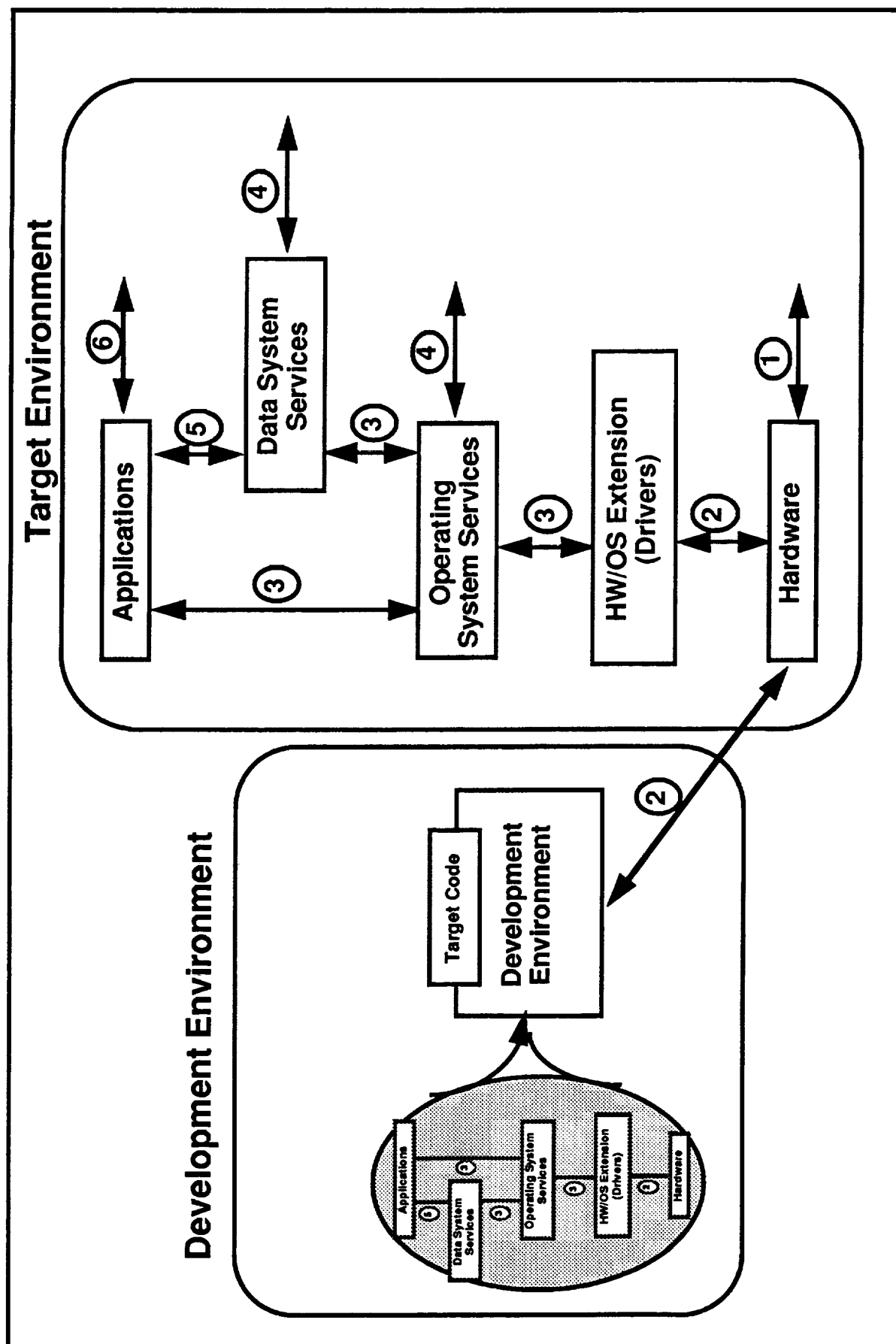Figure 6-3. The Architecture Interface Model is Recursive

Figure 6-4. The Interface Model Applies to Target and Host Development Environments

6.8 PURPOSE OF PROFILES

As described in [POSIX91], profiles define the combinations of base standards and profiles (i.e., templates) for the purpose of:

- Identifying the baseline standards, together with appropriate classes, subsets, options, and parameters, that are necessary to at least accomplish interoperability, portability and other identified capabilities.

- Providing a system of referencing the various uses of baseline standards that is meaningful to both users and suppliers

- Enhancing the availability for procurement of consistent implementations of functionally defined groups of baseline standards that are expected to be the major components of real applications systems

- Promoting uniformity in the development of conformance tests for systems that implement the functions associated with the profiles

6.9 BIBLIOGRAPHY OF USEFUL DOCUMENTS

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